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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

JUNE 1926

SUMMER MEETING NUMBER

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

Hot Dog or Dirigible?

A PARTY of twelve of us motored down to the Atlantic City Speedway Race on May 1st. Winding our way out of the grounds after Harry Hartz had been given the checkered flag, a gentleman came up to the side of our car, holding in one hand a large, red balloon which resembled, in shape, a dirigible. In the other hand he carried a basket full of packages which we supposed contained deflated dirigibles. His cry was, "Buy a balloon—only 10c." One of the party in the rear seat bought two of them. One package was opened, and then started the application of lung power. When the dirigible had reached the size of a hot dog it exploded. The second package was opened. A second hot dog exploded. We all referred to the gentleman as a faker, laughed, and the incident was forgotten.

The gentleman did not tell us the balloons in the packages would inflate to a length of four feet and look like the dirigible which he carried. He offered us balloons for 10c and we drew our own inference and were fooled. In the business world some men do not stop even at inferences. They come right out in black and white and they come right out with talk and offer that which they know (for they are intelligent men) is not fact. This sort of thing should have no place in the Automotive Industry.

No automobile manufacturer would offer for sale a car, beautifully dolled up on the outside, but which would not run. Then why should any automobile manufacturer be fooled into buying *equipment* which does not "run"? Being fooled, when it comes to controlling spring recoil, is an easy matter and hence the motor car manufacturer can be excused if he is fooled. On a mere road test we can be most frightfully fooled. The reason for this is that our eye is the only instrument we have for telling us how this, that or the other bump *should* affect our comfort. Some bumps *look* as though they would throw us a "mile". Other bumps *look* quite innocent. For example:—Along comes a bump which our eye tells us is going to give us an awful jostle. We pass over the bump and we do not get the jostle. We immediately conclude that the devices we are testing are wonderful. But that particular bump might not have jostled us even though we had had no control mechanisms on the car. Hence our conclusion is false. What we *think* a road will do to us and what any given road may *actually* do are often two quite different things. Hence the road-test method is not always to be relied upon. We should supplement our road testing with some real "know" testing.

This we do *know*—The recoil of a car spring can be anything from one ounce up to around a thousand to fifteen hundred pounds. Minutely compressed, the recoil force of the spring will be negligible; fully compressed, it will be frightful. To adequately control this widely varying force a recoil-control mechanism must hold very gently when in one position and must hold variously up to very powerfully for other positions. There is one sure way for any man to *know* just how any recoil-control mechanism *does* hold. Mount the device on a stand similar to the stand illustrated, step on the pedal, and *feel* the resistance offered. The resistance should be powerful as you start to pull the strap out (the resistance at this point should more than support your weight) and this resistance should progressively diminish until it is quite gentle when the pedal is way down and the strap is in the position it would be in when the car is standing at rest. Such action provides resistance which is in proportion to varying recoil forces, and this method of testing is the only one which we know of to actually determine whether or not the device gives proportional resistance and whether or not it gives *sufficient* resistance. This method gives you the same insight into fact as does the application of lung power into the capacity of a toy dirigible. Any car manufacturer who is considering this nature of equipment should install one or more of these simple and inexpensive demonstrating stands in his Engineering Department. This little piece of equipment will tell him exactly what is what—and quickly, and may save him many an error and many a sleepless night.

This is a plea for truth and facts in the Automotive Industry.

John Warren Watson Company

Original and Sole Manufacturers of Stabilation

Twenty-fourth and Locust Streets, Philadelphia

[Detroit Branch: 3021-3023 Grand Boulevard, East]

WATSON STABILATORS

HOLD IN PROPORTION TO THE VARYING FORCES OF SPRING RECOIL

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XVIII June, 1926 No. 6

Chronicle and Comment

Aeronautic Meeting Next

UNDER the chairmanship of W. B. Stout the arrangements for the Aeronautic Meeting are rapidly nearing completion. This popular event will take place at the Bellevue-Stratford Hotel, Philadelphia, on Sept. 2 and 3, the two days preceding the opening of the National Air Races. Further details regarding the Aeronautic Meeting will be found in the pages of this issue of THE JOURNAL.

Sections Committee Meeting

QUESTIONS connected with the financing of Sections, the organizing of Student Groups, the forming of new Sections, the arranging for Section meetings that will be of wider interest to members, and the recent revision of the standard Section Constitution, By-Laws and Rules were discussed at a meeting of the Sections Committee, held at French Lick Springs on June 1. An account of this meeting is printed on p. 529.

Attractive Events Coming

WITH the Aeronautic and Production Meetings in September, the Transportation and Service Meeting in November and the Tractor Meeting in December, the Society will complete its meetings activities for the calendar year. In January the Annual Dinner and Annual Meeting will conclude the present administrative year.

Almost without exception, the individual members of the Meetings Committee and the special subcommittees have been unusually active this year and have succeeded in scheduling a series of meetings that possess great merit from both engineering and social viewpoints.

Interesting information regarding these meetings may be found in the columns of this issue of THE JOURNAL and in succeeding issues. The *Meetings Bulletin* will also bring to the members all pertinent details.

Index to Vol. XVIII.

TO facilitate the appearance of this issue of THE JOURNAL, which contains a news account of the Semi-Annual Meeting of the Society that was held at French Lick Springs, Ind., on June 1 to 4, the index to Vol. XVIII., covering the numbers from January to June, inclusive, has been omitted. This will be printed in separate pamphlet form and mailed as Section 2 of the July issue of THE JOURNAL. The present expectation is that this number will be mailed to the members not later than July 6.

Rims for Low-Pressure Tires

AFTER watching the low-pressure tire situation since the recommendation of the Tire and Rim Division was published in February, 1924, on p. G1 of the S. A. E. HANDBOOK, a further step in the standardization program for low-pressure tires was taken by the Division at a meeting held in Detroit on May 7. At this meeting a limited number of definite rim sizes for low-pressure tires on passenger cars was recommended for adoption by the Society. The detailed account of this action appears on p. 572 of this issue of THE JOURNAL.

Speaking of Speed

AUTOMOBILE TOPICS is deserving of special mention for having reproduced in the June 5 edition the airplane photograph of members and guests that was taken at French Lick Springs on the afternoon of June 2. Under the direction of N. B. Pope, of *Automobile Topics*, the photograph was telegraphed to New York City by the American Telegraph & Telephone Co.

Other trade publications and newspapers showed great interest in the meeting and merit the Society's appreciation for their efforts in bringing important engineering items to the attention of automotive enthusiasts throughout the Country.

The Airplane-Photo Exhibition

UNDOUBTEDLY the most spectacular feature of the Summer Meeting was the airplane-photographic exhibition that was provided in connection with the Army's experimental program through the courtesy of Major J. F. Curry, commanding officer, McCook Field, Dayton, Ohio. Preliminary arrangements for the venture were made by Capt. L. G. Meister, formerly of the Air Service; the photographic airplane was piloted by Lieut. G. W. Goddard, chief of the Aerial Photographic Branch, and the photograph was made by a special quick-work process by Dr. S. M. Burka, of the Aerial Photographic Branch. A number of Dayton Section members cooperated in making the affair a success and, as a

Dayton Section stunt, provided a sufficient number of the photographs for all who desired them.

A report of this event and the "meeting by airplane" stunt will be found in the news account of the meeting.

Over 800 Attend Summer Meeting

WITH an attendance of approximately 820 Society members and guests, exceeding that at last year's meeting by about 100, the Summer Meeting at French Lick Springs, Ind., June 1 to 4, scored a distinct hit from practically every angle. Judging from the number of persons, both ladies and gentlemen, who participated in the varied program and from their favorable comments, the Meetings Committee, L. Clayton Hill, chairman, should feel that the arrangements met with unqualified approval. Events at Indianapolis, including the very successful Indiana Section dinner and the races, formed a fitting prelude to the many enjoyable happenings that followed on the four succeeding days.

Eminently satisfactory was the layout and the equipment at the French Lick Springs Hotel. The housing accommodations, cuisine and service were adequate; an excellent assembly hall was available for the technical sessions and indoor social gatherings; the golf courses met with great favor; and the natural surroundings were in general very attractive.

Included in this issue of THE JOURNAL is an illustrated news account of the meeting, and a majority of the technical papers are presented in full. In this connection members may be interested to know that the publication of the complete account of the meeting was expedited by utilizing the facilities of the overnight Air Mail Service. The happenings at a morning technical session, for example, were recorded in type in New York 48 hr. later.

Responsibility for the success of the Summer Meeting rests with a large number of enthusiastic members whose efforts were highly appreciated. On p. 559, an attempt is made to mention those who participated most prominently.

Operation and Maintenance Amendment Withdrawn

AS is indicated in the news account in this issue of the Business Session of the Summer Meeting, the Constitutional amendment proposed by J. F. Winchester was withdrawn by him at the Society meeting held this month. The members will recall that the effect of this proposed amendment, if adopted, would have been to substitute for the Second Vice-Presidency representing Stationary Internal-Combustion Engineering, a Second Vice-Presidency representing Operation and Maintenance Engineering. In recognition of the importance of operation and maintenance, the Constitution of the Society was amended some years ago to read specifically to the effect that those, of qualifying age, who by previous technical training, experience or occupation are competent "to take responsible charge of automotive engineering work, including operation or maintenance", are eligible to Member grade. This amendment was mainly declaratory of the policy that had been maintained by the Council theretofore in the grading of applicants for membership.

Mr. Winchester did not withdraw the amendment because he had changed his mind as to its basic merit; he felt that, in view of the discussion had as to the desirability of Constitutional amendment on a broad basis, it would be well to defer until a later time action looking toward such representativeness in the personnel of the Council as he had in mind. The discussion mentioned had occurred at a session of the Council, in conference with the Constitution Committee. The Constitution Committee is to make a further study of the whole matter of specific representation on the Council of various phases of automotive engineering. Several of the points involved have been set forth in recent issues of THE JOURNAL this year, particularly in the May number, on p. 474 of which were printed comments of members of the Society. At the meeting of the Society held this month Chairman Scaife, of the Constitution Committee, referred to the necessity of amending the Constitution from time to time to meet changing conditions. Obviously, in addition the provisions of the Constitution of the Society with regard to the conduct of its activities should be forward-looking.

In his Presidential Address of 1919, C. M. Manly emphasized the great importance and the growing importance of engineering work connected with the planning and organizing of automotive-vehicle operation. He remarked significantly that more engineers are engaged in the operation and maintenance of railroads than are engaged in the design and construction of locomotives and railroad cars. Leading members of the Society have expressed doubt whether the general arrangement of representation of various automotive fields on the Council, has not outlived its usefulness, especially from the standpoint of administrative effectiveness. The revision of the Constitution that provided for the establishing of five second vice-presidencies, representing respectively motor-car, tractor, aeronautic, marine, and stationary internal-combustion engineering, was made at the time the American Society of Aeronautic Engineers and the Society of Tractor Engineers were merged with the Society of Automobile Engineers, and the last named, with its name changed to Society of Automotive Engineers, Inc., became active in the fields of these Societies and also in motorboat and in stationary internal-combustion engineering, pursuant to action taken by the National Association of Engine and Boat Manufacturers and the National Gas Engine Association, predecessor of the Gas Engine and Farm Power Association.

Past-President Manly, who is a member of the present Constitution Committee of the Society, has expressed the opinion that it would be a step distinctly in the wrong direction if the accentuation of the fact that the Society is directly and deeply concerned in the promoting of the welfare of each of the general divisions of automotive engineering were to be diminished by the abolishing of the present diversified second vice-presidencies, unless an equally definite method of emphasizing the Society's interest in these and certain other specific divisions of automotive engineering were substituted therefor. Manifestly, much is to be said in favor of the emphasizing of the official interest of the Society in the work of various automotive divisions by allocating to them definitely named representatives on the Council.

As mentioned in the account in this issue of THE JOURNAL of the sessions of the Council held at French Lick Springs this month, that body, upon the recommendation of a committee of men well qualified to give opinion in the matter of the furthering of the interests of motor-vehicle operation and maintenance, decided to authorize the establishing of a general committee to study important phases of fleet operation and maintenance and of service procedure of manufacturers and dealers.

The further comments of the Constitution Committee as to amendments that are necessary or advisable are awaited with interest.

Four Great Days at French Lick

Large Attendance, Interesting Program, Sparkling Weather and Pleasant Surroundings Favor Summer Meeting

With a program brim full of opportunities for discussing matters of business and engineering interest and for the enjoyment of a great variety of recreational pursuits, the 1926 Semi-Annual Meeting of the Society was carried through to completion at French Lick Springs, Ind., on June 1 to 4, inclusive, with scarcely a "hitch." Many of the 850 members and guests greatly enjoyed the Indiana Section Dinner at Indianapolis on May 30 and the races on May 31, before proceeding to the scene of the numerous pleasant experiences that filled the 4 following days; members arrived by train, automobile and airplane.

Difficult indeed would be the task of determining the most interesting and noteworthy of the many features that were provided by the Meetings Committee. Technical sessions were well attended, and great interest was shown in practically all entertainment and sports events. Seldom if ever before have the various Sections provided a stunts program of as great merit as that at French Lick. Indiana, Detroit, Cleveland, Chicago, Dayton, and Metropolitan were heard from in this connection.

News Account Follows

In the following columns an illustrated news account of the Summer Meeting is printed. The photographs with few exceptions were made by Nate Lazarnick and his friend, "Will." This issue of The Journal also contains a majority of the Summer Meeting technical papers; others will follow in later issues.

SECTION AFFAIRS FLOURISHING

An Enthusiastic and Well-Attended Committee Meeting Held at French Lick

Several very important matters were thoroughly but expeditiously considered at the meeting of the Sections Committee which took place at French Lick Springs on June 1, under the able direction of Chairman J. H. Hunt. Eleven members of the Sections Committee attended the meeting, and the presence of six other interested Section members gave added vitality and value to the discussion.

Section finances was the first question to receive attention. The Committee endorsed the budget system and the present method of administering it by having each Section reimbursed for its expenditures upon submitting receipted vouchers to the central office monthly. In certain cases where vouchers are not obtainable, they will not be required, and minor expenditures will be taken care of by a petty cash account. If any Section for some local reason finds it impracticable to conform in every particular to the standard practice, the Sections office will work with the individual Section to make any necessary adjustment.

Problems connected with the desire of the Sections to furnish free dinners and other entertainment on various occasions were brought up. The original idea, it was stated, was to have such entertainment self-supporting, and it was the sense of the meeting that a Section unquestionably had the right to stage an entertainment if the Section is self-supporting or if it obtains, by the sale of tickets or by any independent source of revenue, enough money to pay for the entertainment in question, provided that the affair is of a nature to reflect credit on the Society and the Section. Those present at the meeting believed that the holding of Section dinners and other affairs of a social nature is desirable from the viewpoint of increasing membership and encouraging larger attendance at meetings. It was felt that it would be difficult and impracticable to formulate a set of rules covering this problem, as the question is of such a nature as to narrow itself down to specific cases, each of which must be settled on its own merits. The Committee believed, however, that each Section planning to give a free dinner or other entertainment should consult the Council well in advance of the proposed event.

A charter, drawn up by the students composing the recently organized Ohio State University Student Group, was submitted for the approval of the Committee. It was decided that the Chairman should appoint a sub-committee to study this charter and to consider the advisability of putting it into such shape that it can be adopted as a standard charter, with only slight revisions, if any, by Groups that may be subsequently organized. This sub-committee will consider also the possibility of increasing, in colleges and universities, interest in automotive engineering by offering a prize for a paper or series of papers on some appropriate topic. The sub-committee will report later by mail to the main Committee.

Meetings held in St. Louis by a number of Society members were commented on by the Committee, and much interest was expressed in the activities of this informal group.

The advisability of having on Section programs more

papers of interest to production men was stressed, and a lively discussion ensued, as various means for achieving the desired results were suggested.

The proposed revision of the standard Section Constitution, By-Laws and Rules, which was approved by the Sections Committee in January, had been placed before each Section during the spring and slight revisions made. Page proofs, incorporating all revisions, were submitted to the Committee, and the document as revised was given the unanimous approval of those present.

ALL STANDARDS SUBMITTED APPROVED

Division Report on Low-Pressure Tire Rims Acted Upon at a Special Meeting

K. L. HERRMANN

The Division recommendations as printed in the May issue of THE JOURNAL were submitted for the approval of the Standards Committee at the meeting on June 1 with the exception of the recommendations on Army-Navy Standards, Lighting-Plant Ratings and Electric Incandescent Lamps. The remaining recommendations were approved by the Committee as submitted and were subsequently approved by the Council and at the Business Session of the Society.

An additional recommendation covering low-pressure tire rims, not printed in the May issue, was submitted for approval by the Tire and Rim Division. This recommendation, which is given on p. 572 of this issue, was acted upon at an adjourned session of the Standards Committee, being approved as submitted with the exception of the addition of the 20 x 4-in. rim. The report was approved also by the Council and at an adjourned Business Session of the Society held Thursday morning immediately preceding the Race Session.

The recommendations as actually submitted by the Divisions varied somewhat from the reports as printed in THE JOURNAL. An order of business listing all changes in the recommendations was given out at the meeting. These changes, together with the discussion at the Standards Committee Meeting, will be printed in full in the July issue of THE JOURNAL so that the recommendations can be voted upon by the members with a complete knowledge of the action taken.

The Standards Committee Meeting was held at 5 o'clock in the main dining-room of the hotel, but owing to the lack of discussion, the 35 recommendations were all acted upon by 6:30 p. m. In the absence of Chairman F. A. Whitten, Vice-Chairman Karl L. Herrmann presided. The reports were submitted by the respective Division chairmen, who sat with Chairman Herrmann at the head table.

The recommendation covering the Army-Navy Standards was not submitted for action as it was decided shortly before the meeting to withhold the report until after the Aeronautic Division meeting, which is to be held in the near future to consider the possibilities in aeronautical standardization. The recommendation on lighting-plant ratings did not meet with the approval of all of the Division members and it was consequently desired to have the Division reconsider the proposal before final Standards Committee action. The subdivision on Electric Incandescent Lamps held a meeting preceding the Standards Committee Meeting owing to criticism that had been received as a result of publication in THE JOURNAL. Owing to a large number of changes that it is thought will be made during the next few months as a result of development work now under way, it was considered inadvisable to submit the report at this time. The report will probably be ready for action at the January, 1927, meeting of the Standards Committee.

As stated in the recommendation on Screws, Bolts and Nuts on p. 436 of the May issue of THE JOURNAL, a supplementary report covering a schedule of thread lengths too short to take the length of thread specified in the proposed formulas was submitted by the Screw-Thread Division and met with general approval.

KETTERING ON RESEARCH WORK

Sketches Development Through 4000 Years and Tells of Present Trend

The research engineer of today stands for something different from ever before; he is interested in producing a better article, in facilitating the conversion of raw materials into finished products and in raising the culture and intellect of the people. Thus C. F. Kettering, head of the General Motors Corporation Research Laboratories, concluded a brief address at the General Session of the Summer Meeting on Tuesday evening, June 1.

About 4000 years ago, he began, a Chinaman threw a cocoon into some hot water and discovered that the fiber became loosened so that it could be unwound. Then it was found that the fiber could be twisted into thread and woven into silk fabric. Through the succeeding thousands of years considerable study and work was devoted to the improvement of mulberry trees and the feeding of the silk-worms to produce larger cocoons and better silk fabrics. In recent years a satisfactory process has been developed for the production of artificial silk, now called Rayon.

This development was cited, said Mr. Kettering, as an example of what ingenuity and research will do for the human race. Artificial silk is the first human-made fabric. Heretofore we have simply appropriated natural fibers. Similarly, in foodstuffs, we use that which nature produces, as meats and vegetables, but when chemists have learned enough about digestion and metabolism it will be possible to produce artificial food. Only within recent years has the importance of vitamins been discovered.

WIDE FIELD FOR ORGANIC CHEMISTRY

The speaker then referred to the investigations by Dr. Walter Reed into the cause of yellow fever, which he found was transmitted solely by one species of mosquito; to the work of Dr. Gorgas in draining the swamps so that the Panama Canal could be built without interference from the disease; and of the discovery in Africa that sleeping sickness is transmitted by the tsetse fly from the blood of alligators. These examples were given to show that former lack of knowledge was due to the fact that in previous investiga-

L. CLAYTON HILL

C. F. KETTERING

tions not all the factors were known. A tremendous field in organic chemistry has been opened, said Mr. Kettering. Ehrlich, a dye chemist, found that methylene blue, when injected into the human body, was absorbed only by the nerve tissue and one of the results was the production of the curative drug salvarsan.

Now Seeking Cultural Development

Referring to engineering, he said that a difficult problem is one that we do not know enough about and that when a man says a problem is too hard he means that he is too soft to solve it.

Every once in a while the banking interests say that the automobile business is not on a sound basis; nevertheless, savings-bank deposits have increased in proportion to the purchase of automobiles. Thrift is not saving without spending but lies in increasing the production of articles of use. American workmen, with the aid of machinery, convert 30 times as much raw material into motor cars as the German workman and consequently can have more of the necessaries and luxuries of life. It is not a question of wages but of production. In this Country we have solved the problems of producing sufficient of the necessities and have turned to the production of luxuries and means for intellectual and cultural development.

SOCIETY'S CONDITION SATISFACTORY

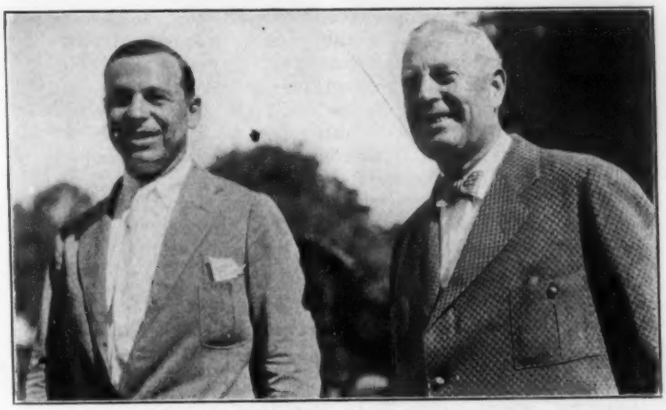
President Litle, at Business Session, Says Engineer Is Coming Into His Own

In opening the Business Meeting of the Semi-Annual Meeting on Tuesday evening, June 1, President Litle said that the condition of the Society, as shown by the Committee Reports for the first half of the year, is very satisfactory. These reports were not presented verbally but were distributed in mimeographed form. A summary of them is given elsewhere in this issue. Applications for membership in the Society during the last year were almost double the number received in the year beginning May, 1923, and ending April, 1924. The Sections have been very active during the past winter and there are rumors of other Sections to be formed, although there was nothing definite to report as yet. The Society is now so large that it cannot well hold more than two general meetings per year in addition to the special-subject meetings.

In his welcoming address, President Litle said that the engineers are all powerful in shaping the destiny of the automotive industry, all look to them for inspiration and suggestions, the industry is showing greater interest in the activities of the Society, and unquestionably the engineer is coming into his own in American industry. From what he saw at the Indianapolis race on May 31, he believes that we shall soon see on the American market some of the high-speed "toy" engines, probably equipped with some form of supercharging device. They will fit in nicely with cars of the future, which must be lighter and smaller than any we are now using but be equipped luxuriously. American supercraftsmanship will be reflected in their design, Mr. Litle declared.

Council Approves Standards

First Vice-Chairman K. L. Herrmann, of the Standards Committee, reported that at the afternoon meeting of the Committee all of the reports awaiting action, as published in the May issue of THE JOURNAL, had been approved with the exception of the Army-Navy Aeronautic Standards, the Lighting-Plant Ratings and the Incandescent-Lamp Specifications, which had been withdrawn, and the Balloon-Tire Rim Sizes, the discussion of which had not been finished at the time of the Business Session on Tuesday evening. The Council had acted favorably on the proposed standards, he said, and the reports were ready to be submitted to the members for a letter-ballot vote. He moved that they be so submitted, and the motion was seconded and carried unanimously.



Two Representatives of the Gabriel Organization
George Ralls, President, (at the Left) and at the Right His Predecessor, C. H. Foster, Who Is Now Chairman of the Board

Constitutional Amendment Withdrawn

President Litle announced that the Constitution Committee was not ready to present a report on the proposed amendment to the Constitution of the Society relative to establishing a vice-presidency representing operation and maintenance. J. F. Winchester, who had originally moved the amendment, explained that it is now proposed that the Constitution Committee review the entire Constitution with a view to its amendment as regards representation on the Council, and therefore he withdrew his motion for the proposed amendment at this time. This motion of withdrawal was seconded and carried.

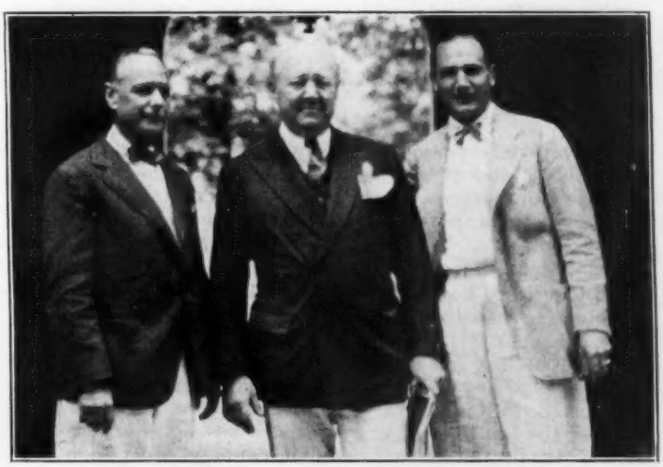
COMMITTEES REPORT PROGRESS

Various Main Committees of Society Narrate Activities Since Annual Meeting

In the following columns will be found comprehensive abstracts of the activity reports that were presented by the Chairmen of various committees at the Semi-Annual Meeting at French Lick Springs. The period covered is from the Annual Meeting in last January to June 1, the date of the Semi-Annual Business Meeting.

Highways Committee Report

In reporting on the work of the Highways Committee since the 1926 Annual Meeting, B. B. Bachman, the chairman, stated that



A Trio of Summer Meeting Attendants
From Left to Right They Are C. A. Musselman, F. E. Moskovics and G. A. Hoeveler

The Highways Committee has continued to act as the point of contact for the Society with the motor-truck impact-tests made at the Bureau of Public Roads. The Rubber Association of America is the third party interested in the research.

The investigation was authorized and instituted in 1923. At first, effort was concentrated on the development of an accelerometer to be used in the research, and then, in the summer of 1924, a start was made on the tests included in the program. The objects to be accomplished were a determination of

(1) Cushioning effect as influenced by the various tire, truck and road factors
(2) Road stresses as influenced by motor-truck wheel-impact.

The major part of the effort has been devoted to the first object. The tests originally scheduled have been completed, and the data are available in standardized final form. An account of this work will be given at the Tire Session of the Summer Meeting in a paper to be presented by J. A. Buchanan and J. W. Reid.

The future program will include cutting down and testing cushion and solid tires. Additional tests will be made with such recently designed tires as properly come within the scope of the investigation and have been placed in general service. Further research on the instrumentation is also planned, and the possibility of including in the tests a six-wheel truck equipped with solid tires has been suggested.

Meetings Committee Report

Chairman L. Clayton Hill of the Meetings Committee submitted the following report of meetings activities.

At the January Session of the Meetings Committee, plans were laid to hold, during the present administrative year, a Semi-Annual Meeting; an Aeronautic Meeting; a Production Meeting; a Transportation and Service Meeting; a Tractor Meeting, in cooperation with the American Society of Agricultural Engineers; the Annual Dinner; and the Annual Meeting. In the interests of concentration and efficiency it was decided to inject the service and maintenance topics in the program of the Transportation Meeting.

THE SUMMER MEETING

In selecting French Lick Springs as the site for the 1926 Summer Meeting, the Committee was guided by the returns from a questionnaire that was circulated among the members. Niagara Falls, N. Y.; Spring Lake, N. J.; White Sulphur Springs, W. Va.; and French Lick Springs, Ind., were mentioned as possible meeting places, and those who returned the questionnaire favored French Lick Springs rather strongly. The attendance, over 800 at the meeting, indicated very clearly that the choice was a popular one.

THE AERONAUTIC MEETING

Immediately preceding the opening of the National Air Races and surrounded by features of the Sesqui-Centennial celebration, the Aeronautic Meeting should offer a wide appeal to all persons interested in aeronautic matters. It will be held at the Bellevue-Stratford Hotel, Philadelphia, Sept. 2 and 3.

Under the Chairmanship of W. B. Stout, a special committee including in its membership Paul Henderson, Glenn Martin, Ralph Upson, E. P. Warner, and J. E. Whitbeck has well under way the arrangements for three technical sessions, a banquet and an inspection visit to the Naval Aircraft Factory. Included among the topics to be discussed are air-cooled engines for aircraft, the economical and rapid production of all-metal airplanes and seaplanes, airplanes for individual ownership, equipment and methods for aircraft operation, and prophecies for the future of aviation.

THE PRODUCTION MEETING

Conveyors, gear production, machine tools, and inspection will be discussed at the technical sessions of the Society's Production Meeting that will be held concurrently with the Annual Meeting and Exhibition of Machine Tools and Heat-treating Equipment of the American Society for Steel Treating. The Committee in charge of this important event in the Society's Meetings Calendar is under the chairmanship of V. P. Rumely and includes in its membership George Babcock, Eugene Bouton, W. G. Careins, C. B. Durham, A. H. Frauenthal, Paul Geyser, R. M. Hidey, R. R. Keith, Joseph Lannen, L. F. Maurer, T. Milton, P. J. Morhan, Louis Ruthenburg, and P. L. Tenney.

At least two plant visits of unusual interest to production men are being arranged through the cooperation of prominent members.

Replacing the usual production dinner, a Stag-Carnival will be staged under the guidance of T. Milton and the members of his local Reception and Entertainment Committee.

Members of the American Society for Steel Treating will be cordially invited to participate in all activities connected with the Production Meeting, and it is understood that members of our Society will be accorded similar privileges by the American Society for Steel Treating.

The Production Meeting will be held at the Hotel Sherman, Chicago, Sept. 21 to 23.

THE AUTOMOTIVE TRANSPORTATION AND SERVICE MEETING

J. F. Winchester, chairman of the Automotive Transportation and Service Meeting Committee, has chosen, as members of his committee, H. R. Cobleigh, C. O. Guernsey, A. W. Herrington, F. C. Horner, Frank E. H. Johnson, A. F. Masury, V. A. Nielsen, L. H. Palmer, R. E. Plimpton, A. J. Scaife, F. J. Scarr, E. W. Templin, and G. S. Whitham. The meeting will be held at the Copley-Plaza Hotel, Boston, Nov. 16 to 18.

Arrangements have been practically completed by the Committee for three technical sessions during which the discussion will be concentrated on problems of design, engineering, operation, and maintenance of trucks and motorcoaches. Special consideration will be given to the operation and maintenance of these vehicles in coordination with railroad operation.

An inspection visit to the maintenance plant of the Standard Oil Co. at Cambridge, one of the largest and best equipped of its kind in the Country, has been arranged. At least one of the technical sessions will be held at the Massachusetts Institute of Technology.

An Automotive Transportation and Service Meeting Banquet will be held on the evening of the second day. It is expected that Governor Fuller of the Commonwealth of Massachusetts will honor the members and guests by his presence.

Members of associations and societies interested in automotive transportation topics will be cordially invited to attend the technical sessions.

THE TRACTOR MEETING

Originally scheduled to be held in March the Tractor Meeting was postponed until early in December. It will be held in cooperation with the American Society of Agricultural Engineers.

Under the chairmanship of O. W. Sjogren, the Tractor Meeting Committee that includes as its members J. F. Max Patitz, O. W. Young and O. B. Zimmerman has arranged for two technical sessions during which will be discussed such topics as Production of Tractors and Farm Equipment, Utilization of Heavy Fuels in Tractor Engines, Industrial Application of Tractors, and Application of Tractor and Automotive Equipment to Road Building and Maintenance.

Earl Gunn

E. C. Mugford

M. L. Heminway

R. P. Johnson

FOUR OF THOSE WHO ATTENDED THE MEETING

THE ANNUAL DINNER

The Meetings Committee is already giving attention to tentative arrangements for the Annual Dinner that will be held at Hotel Astor, New York City, during Show Week. H. O. K. Meister has been chosen by President Litle as chairman of the dinner committee.

1927 ANNUAL MEETING

Members of the Meetings Committee are devoting thought to the matter of selecting suitable topics and competent speakers for the 1927 Annual Meeting.

MEMBERSHIP COMMITTEE REPORT

The following report covering the work of the Membership Committee was received from the chairman, H. L. Horning:

Thanks to the continued support and cooperation that the members of the Society and the officers of the Sections have given the Membership Committee, there has been received at the Society's headquarters, since Jan. 1, an average of more than 89 applications per month. During the month of April 101 applications were received. In the 12 months, ended April 30, 1926, a total of 1009 applications had been received.

The statistics printed below indicate very clearly the trend of the membership for the last 3 years and for the current year up to May 1. Since May 31, 1924, the receipt of applications has advanced from a low average of 46 per month to a high average of 84 per month for the preceding year. Members qualifying have advanced from a low average of 35 per month to a high average of 64 per month. Members dropped, resigned and deceased fell from a high average of 64 per month to about 38 per month. At the present time there are slightly in excess of 500 members who owe dues for the current year. It is expected that about 40 per cent of these members will pay their dues before the end of the fiscal year. This will reduce the average number dropped for non-payment of dues, resigned and deceased this year to about 35 per month. On April 30 there was a net gain of about 300 members over last year. We anticipate a net gain of about 500 members for the year. On May 1 there were about 235 applications awaiting action by the Grading Committee and Council.

APPLICATIONS FOR MEMBERSHIP RECEIVED

	1923–4	1924–5	1925–6
May	59	115	117
June	56	63	91
July	36	35	62
August	25	41	62
September	35	56	66
October	50	82	87
November	49	60	74
December	39	77	92
January	52	79	84
February	54	66	99
March	55	71	74
April	70	81	101
	580	826	1,009

MEMBERS QUALIFIED BY PAYMENT OF INITIATION FEE AND DUES

	1923–4	1924–5	1925–6
May	103	12	74
June	29	71	39
July	44	95	92
August	20	47	39
September	16	10	18
October	51	58	33
November	61	54	106
December	35	56	76
January	64	81	84
February	19	69	54
March	44	45	91
April	24	56	59
	510	654	765

The following is a 2-year comparison of the membership by grades as of April 30:

	1925	1926
Members	2,783	2,834
Service Members	79	95
Foreign Members	101	116
Total Member Grade	2,963	3,045
Associates	1,586	1,781
Juniors	479	486
Affiliates	107	109
	5,135	5,421
Affiliate Representatives	197	195
	5,332	5,616
Enrolled Students	234	233
	5,566	5,849

It will be noted that there is an increase in every grade of membership.

PUBLICATION COMMITTEE REPORT

E. P. Warner, chairman of the Publication Committee, reported as follows:

While the Society's publication work has declined slightly in the period from Jan. 1 to May 8, 1926, as compared with the last 6 months of 1925, the volume nevertheless is greater as regards the number of papers, discussions and contributed articles published in the five issues of THE JOURNAL, January to May inclusive, as compared with the corresponding issues for 1925. In the first five issues of THE JOURNAL for

this year 69 papers, discussions and contributed articles were published. The total number of pages in these five issues was 1191 of which 567 pp. were text. The figures for the corresponding issues of 1925 are 64 papers, discussions and contributed articles, 1115 total pages and 595¼ text pages. Comparative figures on the total number of pages in THE JOURNAL, the number of text pages, the proportion of text pages and the number of papers, discussions and contributed articles printed in THE JOURNAL for the two 6-months' periods of 1925 and the first five months of the current year and 1925 are given below.

	January-May, 1926	January-May, 1925	January-June, 1925	July-December, 1925	January-December, 1925
Total Number of Pages	1,191	1,115	1,330	1,404	2,734
Number of Text Pages	567	595¼	702¾	681¾	1,384½
Percentage of Text Pages	47.5	52.3	52.7	48.6	50.8
Papers, Contributed Articles and Discussions Published	69	64	75	83	158

As in the past efforts have been made by a careful selection from the papers presented at meetings and articles contributed for publication to print only such material as has permanent value and this is supplemented by thorough editing to eliminate all superfluous matter as far as possible. This policy of careful selection is reflected in a smaller percentage of papers and articles printed in THE JOURNAL that are not approved by the Publication Committee for inclusion in the Transactions for a 6-months period.

The February issue of THE JOURNAL, which contained the news account of the Annual Meeting in Detroit last January was the largest number published since the establishment of THE JOURNAL in July, 1917. This number contained 177½ pp. of text out of a total of 320, both figures being records.

TRANSACTIONS

Part II of the 1924 TRANSACTIONS was issued on April 15, 1926. This volume consisted of 724 pp. and contained 30 papers. The preparation of copy for Part I of the 1925 TRANSACTIONS will be completed in the very near future. It is expected that this volume, which will contain 27 papers and consist of approximately 570 pp., will be mailed to the members some time this fall. At the present time the Publication Committee is considering a preliminary list of 75 papers for inclusion in Part II of the 1925 TRANSACTIONS.

In determining the inclusion or exclusion of a paper in the TRANSACTIONS the basis for committee action is whether or not the paper or contributed article possesses permanent value and really adds to the structure of engineering knowledge. For this reason some material, while possessing great current interest at the time of its publication in THE JOURNAL, fails to secure a place in the TRANSACTIONS. The number of papers submitted to the Publication Committee for consideration in connection with the last three parts of the TRANSACTIONS, the number of papers included and the proportion of such papers to the total number considered are tabulated below.

	Number of Papers Considered	Number of Papers Included	Percentage of Papers Included
Part I, 1924	59	28	47.5
Part II, 1924	56	30	53.6
Part I, 1925	42	27	64.4

This increase in the percentage of papers printed in THE JOURNAL and included in the TRANSACTIONS for a 6-months period indicates the care that is taken in the selection of papers and contributed articles for publication in THE JOURNAL originally.

As in the past reprints have been furnished to authors and interested organizations. In the 5 months covered by this report 11 such reprints were handled by the Publication Department. The total volume of this work was 100½ pp. and ranged from 50,000 copies of a ½-page leaflet to 50 copies of an 8-page pamphlet.

The policy of printing illustrated news stories of Society and Section meetings held the previous month in the Meetings of the Society department of THE JOURNAL has been continued. In this way it has been possible to call to the attention of the members every paper presented at a Society or Section meeting in the period covered by this report. At this time 15 papers have been approved for publication, 13 are being considered and 26 others have been sent out to the authors and discussers for the correction of their remarks before publication, as compared with 25, 4 and 9 at the time of the last Annual Meeting.

RESEARCH COMMITTEE REPORT

The following report was submitted by Chairman H. C. Dickinson of the Research Committee:

The Research Committee's activities fall into two general divisions. The first is the study, carried on, either by the Society alone or in cooperation with other organizations, of broad general problems arising in the automotive industry. The second is service to individual members through the medium of the Research Department. Reports on the several subjects included under the first heading are set down below under their respective subject titles. The second has received attention in connection with Routine Activities.

COOPERATIVE FUEL RESEARCH

In its study of motor-fuel and its uses, the Research Committee has continued to work in cooperation with the American Petroleum Institute, the Bureau of Standards and the National Automobile Chamber of Commerce. All aspects of the fuel problem are therefore given due weight in the research pursued.

The performance of motor-fuels and methods of measuring their volatility and crankcase-oil contamination have constituted the three major divisions of the Cooperative Fuel Research. To obtain further data on performance, tests have been made of the effect of engine-speed on starting and on fuel-atomization. Much thought has been given to selecting, for future research, fields that will yield most valuable results. The program laid out includes tests on fuels and engines as regards acceleration and performance during the warming-up period. It is to be concerned mainly with the lower part of the distillation-curve, the 5, 10, 20, and 50-per cent points having been selected for particular study. Concentration on these points was decided on at the last meeting of the Cooperative Fuel Research Steering Committee, in view of the fact that the 1922-3 economic motor-fuel survey had indicated the effect of the 90-per cent and the end-points on performance, and in view also of the present economic balance between gasoline and kerosene.

Detonation is a subject that must enter into an up-todate study of fuel-performance. The part selected for the present for the Cooperative Fuel Research is a survey of the methods now in use for measuring the anti-detonating qualities of motor-fuels.

Since the first of the year, laboratory test-methods for measuring fuel-volatility have been further investigated. Brief progress reports on this phase of the Cooperative Fuel Research were given at the Annual Meeting and in the April issue of THE JOURNAL. One of the methods developed is designed to test the volatility of a fuel for starting purposes. With this a determination can be made of the ability of any given fuel to produce an explosion at a given temperature with a given fuel-air mixture. With the second test-method, so far as present experiments indicate, measurements may be made of the fuel-volatility over the whole range from 0 to 100 per cent evaporated, thus

giving a goal for designers of engines and carbureters. T. S. Sligh, Jr., is to present a paper entitled Gasoline Testing at the Fuels and Lubrication Session of the Summer Meeting. Further research will be directed toward the perfection of the methods referred to and a determination of their limits of usefulness.

In connection with its investigation of contaminated crankcase-oil, the Cooperative Fuel Research Steering Committee is indebted to 61 service-stations, representing approximately 10 different car-manufacturers and located in various parts of the Country, for the collection of used oil from about 700 cars. This active cooperation has given the survey a national scope and has materially furthered the finding of interesting and valuable results.

Two collections of oil samples were made, one during the 1924-5 season, and the other just completed early this spring. Chemical analyses of both sets have been made by the Bureau of Standards, and the Research Department has assembled and interpreted the data obtained. The results of this work are incorporated in a paper entitled Causes of Wear and Corrosion in Engines presented by the Research Manager on the afternoon of June 3.

HEADLIGHTING

Satisfactory head-lamps undoubtedly enlarge the sphere of motor cars. The complex question of what is satisfactory light distribution for automobile driving has therefore been given much attention. In the study of this subject, carried on in cooperation with the Illuminating Engineering Society, through the agency of the Joint Steering Committee of the two Societies on Headlight Research, definite progress has been made.

In a motion passed at its first meeting on Jan. 12, 1926, the Joint Committee stated that its first objective was

> To stimulate and guide experimental research directed toward the determination of the most satisfactory methods of automobile-headlighting and, in accordance with the results of research, to formulate a code of recommended practice with respect to head-lamp equipment, adjustment and use.

At that time a program was formulated consisting of four main topics which may be summarized briefly as follows:

(1) The collection of data now available on the illumination required for the visibility of substantial objects under conditions analogous to those of the headlighting problem
(2) Fundamental studies on visibility and illumination as related to the headlighting problem
(3) Status of the art
(4) Symposium of opinion on ideal headlighting

The Society is grateful to Dr. Percy W. Cobb for his report entitled Visual Fundamentals in the Headlighting Problem presented at the May 4 meeting of the Joint Committee in fulfillment of part (1) of the program. At the same meeting, A. W. Devine presented a valuable report entitled Survey of Present Automobile Head-lamp Equipment, based on extensive observations made in the State of Massachusetts. This constitutes an important contribution to part (3) of the program, and Mr. Devine will continue his investigation in this field.

Achievements under part (4) will be more fully detailed at the Headlighting Symposium to be held on the evening of June 2. Briefly, a form of headlight test-equipment has been developed and specifications for it drawn up. Six sets of the test-equipment have been assembled. Demonstrations with them will be made following the Headlighting Symposium, by car builders and others interested, to show the methods of adjustment and the possibilities involved in their use. Car builders will then be given the opportunity of acquiring these equipments through the Research Department, so that they may participate in the Symposium of Opinion on Ideal Headlighting, to be held at a later date at the General Motors Proving Grounds.

RIDING-QUALITIES

The Society's research on riding-qualities has been mainly concerned with a study of the value of the contact-type of accelerometer in measuring the shocks felt in motor-vehicles. A report on some of this work was published in the Automotive Research columns of the March issue of THE JOURNAL. Further study will be made along these lines in the effort to find some method measuring the riding-qualities of a motor car that will be generally acceptable.

ROUTINE ACTIVITIES

About 2000 letters have been written since the first of the year, in assisting in the execution of the Society's research projects and in answering inquiries for information from individuals. In subject matter the inquiries range from technical details to bibliographies and the making of photostats for articles and papers out of print.

The card index of articles appearing in THE JOURNAL and other technical publications has been increased since Jan. 1 by about 1800 cards. The index of THE JOURNAL and the TRANSACTIONS has an especially useful purpose, since it serves to some extent as a substitute for a cumulative index to the Society's publications.

Of technical magazines other than THE JOURNAL, about 175 separate issues a month are perused. The best articles appearing in these, to the number of about 30 per month, are abstracted for the Notes and Reviews columns of THE JOURNAL. Books of technical interest are also reviewed and added to our Library for the use of members. During the last 5 months about 150 pamphlets and clippings have been added to the Technical Information File. In this is kept only material that has been carefully selected and is thought to be of permanent value.

Contact has been maintained with the research work carried on at universities, and articles on this and other research topics have been furnished each month for the Automotive Research columns of THE JOURNAL.

SECTIONS COMMITTEE REPORT

J. H. Hunt, chairman of the Sections Committee, reported as follows:

> The Sections of the Society have, in practically all cases, been very active and flourishing. Fifty Section Meetings have been held during the period covered by this report, at which the attendance has been excellent and the technical papers have been interesting and instructive; inspection visits that have been arranged by several of the Sections have proved to be very profitable. The need for increased consideration of production matters on Section-meeting programs has been given attention, and it is believed that the technical sessions for the ensuing year will contain much valuable material on this important topic.
>
> Activities that have received the consideration of the Sections Committee since the Annual Meeting are outlined in the succeeding paragraphs.

STUDENT GROUPS

Pertinent information relative to the formation of Student Groups has been sent by the Sections Committee to the proper department of 19 prominent educational institutions. The letter conveying this information mentions the inauguration of a Student Group of the Society at the Ohio State University, points out the possibility of the establishing of similar groups in other colleges and universities to enable the students

to maintain an organized contact with progress in the field of automotive transportation and outlines briefly the benefits to be derived from student membership in the Society.

A charter, drawn up by the Ohio State University Student Group, has been received at Headquarters and submitted to several persons who were well-qualified to discuss it. Those who have considered the matter believe that a standard document might be formulated which would apply in general to all Student Groups, and this matter will be thoroughly discussed by the Sections Committee.

PROSPECTIVE SECTIONS

Society members in the vicinity of St. Louis have expressed an interest in forming a Section in that locality. With this idea in mind, they have been holding meetings all spring and have displayed much enthusiasm.

A member of the Society in Canada has recently written to ask the conditions that must be met before a Section can be formed, as he believes that there is a need for such an organization in his vicinity. The information has been transmitted to him.

SECTION MEMBERSHIP

Section-membership figures of interest are shown in the following table:

Sections	Total Membership 1924	1925	1926
Buffalo	47	68	90
Chicago	122	238	268
Cleveland	137	228	258
Dayton	62	88	66
Detroit	378	604	743
Indiana	44	85	100
Metropolitan	327	508	620
Milwaukee	—	82	89
New England	35	130	127
Northern California	—	—	53
Pennsylvania	64	169	209
Southern California	—	—	59
Washington	13	48	60
	1,229	2,248	2,742

SECTION FINANCES

The Committee has recorded its attitude that the budget system of administering Section finances should be retained and that additional efforts should be made to accomplish the purpose of the budget. The suggestion was made at the meeting of the Committee on Jan. 27 that Sections should submit monthly, to Society headquarters, vouchers showing their expenses for the preceding month and that the Society should reimburse them for the money thus spent, the idea being that in this way each Section would always have its bank balance held to a certain amount. Opposition to this plan has emanated from only one Section; the scheme is being held in abeyance pending thorough discussion by the Committee at the Summer Meeting.

Further consideration has been devoted to the matter of Section expenditures for free dinners and other entertainment. The Committee concurs in the main with the Council's recommendation of May 22, 1924, that Section funds should not be used for these purposes, but feels that the ruling should be modified to take care of the following cases: (*a*) a Section that is supported during any year entirely by dues collected and (*b*) a request from a Section for permission to furnish a free dinner or other entertainment on some specific occasion, such request being received at headquarters too late to obtain approval from the Council prior to the event for which the appropriation is asked. A proposed modification has been submitted to the Council and has been referred by that body to the Sections Committee for discussion at the Summer Meeting.

SECTION CONSTITUTION

The standard Section Constitution, By-Laws and Rules has been revamped and has received the approval of the various Sections. The revised document has been printed and is now, in the form of page proof, pending final approval of the Council and the Sections Committee.

STANDARDS COMMITTEE REPORT

F. A. Whitten, chairman of the Standards Committee, reported that since the January Meeting of the Standards Committee the Divisions have been unusually active as is evidenced by the 37 recommendations submitted at the Standards Committee Meeting on June 1, these recommendations having been approved by the respective Divisions since January. As indicative of the work involved in formulating these specifications, the following list of Subdivision and Division meetings held so far this year is of interest:

DIVISION AND SUBDIVISION MEETINGS

January		
12	Subdivision on Automobile Wiring	Detroit
25	Radiator Division	Detroit
26	Storage-Battery Division	Detroit
27	Subdivision on Signal-Lamps	Detroit
27	Subdivision on Bases, Sockets and Connectors	Detroit
27	Subdivision on Lighting Nomenclature	Detroit
28	Subdivision on Head-Lamp Construction	Detroit
28	Subdivision on Sheet Steel	Detroit
28	Standardization Policy Committee	Detroit
29	Subdivision on Head-Lamp Construction	Detroit
29	Subdivision on Physical-Property Charts	Detroit
29	Production Division	Detroit
March		
4	Subdivision on Insulated Cable	Detroit
11	Subdivision on Generator and Starting-Motor Mountings	Cleveland
23	Subdivision on Black Baking-Enamel	Detroit
April		
2	Lubricants Division	Baltimore
5	Electrical Equipment Division	Cleveland
5	Subdivision on Generator and Starting-Motor Mountings	Cleveland
5	Subdivision on Head-Lamp Construction	Cleveland
6	Subdivision on Carbureters	Harvey, Ill.
6	Lighting Division	Cleveland
7	Engine Division	Chicago
8	Transmission Division	Detroit
9	Parts and Fittings Division	Detroit
12	Screw-Threads Division	New York City
13	Subdivision on Automobile Wiring	Detroit
20	Ball and Roller Bearings Division	New York City
May		
7	Tire and Rim Division	Detroit
11	Iron and Steel Division	Bethlehem, Pa.

The criterion of the standards activity is the number of projects that change their status each month. The average for the first 4 months of 1926 is 29, representing 35 per cent of the total number of subjects assigned during this period. This compares favorably with the averages for the preceding years, which are:

Year	Average Number of Subjects Active Each Month	Percentage of Average Number of Subjects Assigned
1926	29	35
1925	28	40
1924	20	27
1923	21	25

At the present time there are 57 subjects assigned to the Standards Committee, the smallest number under consideration for several years.

The most important feature of the Standards Committee work this year has been the publication of the S. A. E. HANDBOOK as a bound volume. The following is quoted from the Foreword of the March issue:

With the publication of this issue of the S. A. E. HANDBOOK as a bound volume, to be reprinted in revised form semi-annually, it becomes unnecessary for members to keep their handbooks uptodate, to insert new and superseding data sheets and to check the collation periodically. When the S. A. E. HANDBOOK contained only 200 or 300 pp., it was feasible to check the collation of the data sheets semi-annually, but it was an unwelcome task to check the number and date of each page in a handbook containing over 600 pp. In the bound form, specification in a given issue can be definitely understood to represent the most recent action of the Society, provided not more than 6 months has elapsed since the issue was printed.

The need of authoritative information in convenient form as to the sources of supply of parts and materials fabricated according to S. A. E. Specifications has become increasingly apparent in the last few years. The financing of the bound volume by carrying a limited amount of advertising matter makes possible the issuing of such an index. It is believed the index will aid in extending the use in practice of the S. A. E. Specifications, which are the cumulative result of standardization work undertaken through the cooperative efforts of engineers that have been in continual progress since the beginning of automotive standardization 20 years ago.

Advertising in the S. A. E. HANDBOOK is limited logically to advertisements of the S. A. E. Standard parts and materials, which are defined as parts made in accordance with existing S. A. E. Specifications that determine the dimensions necessary to allow interchangeability, and as materials that conform to existing S. A. E. Specifications.

AUTOMOTIVE DIVISIONS

Aeronautic	Motorboat
Agricultural Power Equipment	Motorcoach
Electric Vehicle	Motorcycle
Isolated Electric-Lighting Plant	Motor Truck
	Passenger Car

PARTS OR MATERIAL DIVISIONS

Axle and Wheels	Lubricants
Ball and Roller-Bearings	Non-Ferrous Metals
Chain	Parts and Fittings
Electrical Equipment	Passenger-Car Body
Engine	Production
Iron and Steel	Screw-Threads
Lighting	Storage-Battery
Transmission	Tire and Rim

The Standards Committee, as organized at present, is constituted of 9 automotive divisions representing the automotive-vehicle manufacturers and 16 parts or material divisions representing the various parts and material manufacturers. These Divisions are listed at the bottom of the preceding column.

SECTIONAL COMMITTEES

The Society is now represented on 18 Sectional Committees, being a joint sponsor for 9, organized under the rules of procedure of the American Engineering Standards Committee, of which the Society is a member body.

The reports of the Sectional Committees on the Aeronautic Safety Code and Screw-Threads have been approved and published as American Standards. The Sectional Committees on Ball-Bearings and Bolt, Nut and Rivet Proportions have been active during the year and reports will probably be ready for consideration at the Annual Meeting. The Sectional Committees on Motor-Vehicle Lighting, Numbering Systems for Steels, Pins and Washers, Small Tools and Machine-Tool Elements, and Transmission Chains and Sprockets are being organized.

In addition to the Standards work carried on through the American Engineering Standards Committee, the Society is represented on 18 committees representing the joint activities of other standardizing associations and committees.

INTERNATIONAL STANDARDIZATION

An important step in world-wide standardization activities was taken during the third international conference of the national standardizing bodies of 18 countries in New York City during April at which a proposed constitution was drafted for an International Standards Association. This Association is to be constituted of the national standardizing bodies in all countries accepting the constitution and will influence to a greater or less degree the work of the American Engineering Standards Committee and the Society, especially in those projects for which the Society is a sponsor or which affect the automotive industries.

TREASURER'S REPORT

According to the report submitted by C. B. Whittelsey the adoption of a more conservative policy in the valuation of inventory on the books of account has reduced the balance of the Society's assets over its liabilities. The inventory of publications has been written down to the nominal value of $500 and various items of doubtful value have been materially reduced. The tabulated report of the Treasurer for the first 7 months of the present fiscal year, or from Oct. 1, 1925, to April 30, 1926, is printed below with a comparison with the

R. K. Jack

C. S. Crawford

A. Bachle

H. H. C. Weed

THREE CHIEF ENGINEERS AND AN EXECUTIVE WHO WERE AMONG THOSE PRESENT

Messrs. Jack, Crawford and Bachle Are Associated with the Olds, Stutz and Paige Organizations Respectively. Mr. Weed is Vice-President of the Carter Carbureter Corporation

COMPARATIVE BALANCE SHEET AS OF APRIL 30, 1926, AND APRIL 30, 1925

Assets	1926	1925	Increase	Decrease
Cash	$18,366.60	$18,093.36	$273.24	.....
Accounts Receivable	21,459.34	24,086.81	.....	$2,627.47
Securities—Cost Value	154,998.63	136,410.63	18,588.00	.....
Accrued Interest on Securities	1,563.37	1,777.50	.....	214.13
Inventories	1,403.90	7,901.20	.....	6,497.30
Furniture and Fixtures	4,840.24	7,190.09	.....	2,349.85
Items Paid in Advance, Charges Deferred	8,214.76	12,570.99	.....	4,356.23
TOTAL ASSETS	$210,846.84	$208,030.58	$2,816.26	.....
Liabilities and Reserves				
Accounts Payable	$8,848.04	$6,149.42	$2,698.62	.....
Dues and Miscellaneous Items Received in Advance To Be Credited Monthly to Income	35,967.62	37,229.85	.....	$1,262.23
Reserves Set Aside for Anticipated Expenses	15,494.52	14,349.30	1,145.22	.....
General Reserve	152,985.77	161,954.28	.....	8,968.51
Excess of Expense over Income	2,449.11	11,652.27	9,203.16	.....
TOTAL LIABILITIES AND RESERVES	$210,846.84	$208,030.58	$2,816.26	.....

same period of the previous fiscal year. A comparison of the Society's income and expense for the same periods is presented as is also a comparative balance sheet as of April 30, 1926, and the same date of 1925.

TREASURER'S REPORT

	1926	1925
Budget Income	$192,791.67	$176,166.69
Actual Income—Gross	198,506.90	170,599.76
Income After Deducting Cost of Sales	137,859.19	123,548.69
Budget Expense	192,791.67	176,166.69
Total Expense	199,623.51	183,271.45
Operating Expense After Deducting Cost of Sales	138,975.80	135,200.96
Budget Deficit	.....	6,708.33
Actual Deficit	2,449.11	11,652.27
Securities (Deposited with the Chemical National Bank of New York), Cost Value	154,998.63	136,410.63
Balance of Assets Over Liabilities	152,985.77	161,954.28

RIDING-QUALITIES-RESEARCH PROGRESS

Effective Seat-Cushioning and Axle-Vibration Recording-Devices Described

Mechanical means for attaining greater riding-comfort for motor-vehicle passengers and for producing tangible records of vehicle movements when it travels over the road, so that the actual vibrations become known quantities and therefore can be minimized, constituted the subjects elaborately presented at the Riding-Qualities Session held Wednesday morning, June 2, under the chairmanship of J. W. White, chief engineer of the Wire Wheel Corporation of America, Buffalo. Two papers were presented, demonstrations of the cushioning equipment and of the recording devices being made also by the respective authors.

CUSHION SPRINGS AND RIDING-QUALITIES

In presenting his paper on the foregoing subject, W. C. Keys, manager of the Gabriel Snubber Sales & Service Co., Detroit, said in part that from almost daily contact with the motoring public in the interest of riding-comfort, he is convinced that very great improvements in riding-qualities are possible with little or no additional cost to the car builder and that it is commercially possible to build "riding-luxury" into vehicles which are today barely able to satisfy anyone with respect to comfort. He mentioned four items that determine riding-qualities on any motor vehicle after it is built. From the ground up these are tires, chassis springs, rebound control for the chassis springs, and cushion springs.

According to Mr. Keys, a great contribution to riding-comfort has resulted from the almost universal adoption of low-pressure tires. Experience with these low-pressure tires in the hands of the public has demonstrated that more flexible chassis-springs are necessary; and this combination

INCOME AND EXPENSE COMPARISON FOR 7 MONTHS, OCT. 1, 1925, TO APRIL 30, 1926, AND OCT. 1, 1924, TO APRIL 30, 1925

	7 Months Oct. 1 to Apr. 30 Income and Expense			
Income	1925-1926	1924-1925	Increase	Decrease
Dues and Subscriptions	$46,387.80	$42,523.30	$3,864.50	.....
Affiliated Appropriations	4,375.00	4,375.00	.....	.....
Interest	4,008.25	3,919.89	88.36	.....
Initiations—Net[1]	2,046.43	2,474.06	.....	$427.63
Advertising Sales—Net[1]	78,122.43	66,292.21	11,830.22	.....
Miscellaneous Sales—Net[1]	3,119.28	2,944.81	174.47	.....
Profit on Sales of Securities	.....	1,019.42	.....	1,019.42
TOTAL INCOME	$138,059.19	$123,548.69	$14,510.50	.....
Expense				
Publications	$40,440.90	$39,123.13	$1,317.77	.....
Sections	7,999.44	8,055.40	.....	$55.96
Research	10,594.84	9,580.73	1,014.11	.....
Employment Service	2,418.83	2,747.73	.....	328.90
Standards	11,105.68	14,951.37	.....	3,845.69
Meetings—Net Cost[2]	17,135.71	11,534.67	5,601.04	.....
General Expense	49,280.40	49,207.93	72.47	.....
Undistributed Salaries	1,532.50	.....	1,532.50	.....
TOTAL EXPENSE	$140,508.30	$135,200.96	$5,307.34	.....
Excess of Expense over Income	$2,449.11	$11,652.27	$9,203.16	.....

[1] Direct expenses deducted.
[2] Ticket sales and similar items.

has, in turn, made it essential to employ adequate rebound-control devices. Cushion springs have not shared in constructive development-work to the extent that is necessary and Mr. Keys pointed out that they are fully as important as any one of the other three items.

With reference to cushion springs, Mr. Keys said further that for every motion of the front of a vehicle a corresponding opposite motion takes place at the rear about an imaginary fulcrum-point located somewhere ahead of the rear axle; thus the problem becomes one of cushioning the thrust so imparted to the passenger's body by the seat and the seat-back; hence, both seat and seat-back must conform to the passenger's body and, further, this necessitates the provision of conforming elements as well as spring elements. For these reasons "conforming pads," separate from the cushion springs, are provided.

In the method described by Mr. Keys, use is made also of materials like oilcloth, which is impervious to air, and which by specially constructed valves underneath the seat cushions, enables the employment of the cushioning effect of air under pressure produced by the shocks of vehicle or of passenger movement. In a certain sense the seat cushions act like a bellows, and this effect can be controlled by the size of the valve opening employed in restricting the escape of the air. Seat cushions of curled hair, of modified construction comprising springs in combination with other material and of the new type including conforming pads and air-valve equipment were exhibited, demonstrations and explanations being made of their characteristic reactions when a "passenger" jounced up and down upon them.

Records of Riding-Qualities Tests

One of the chief detriments to the development of accurate riding-qualities instruments has been the lack of satisfactory calibration. In the past, space-time curves have been used largely for calibration but, from the viewpoint of accuracy, these curves generally are acknowledged to be unsatisfactory. In the paper on Instrumentation and Results of Riding-Qualities Tests presented by Roy W. Brown, which is printed in full in this issue of The Journal, beginning on p. 593, an elaborate instrument is described which will produce simple harmonic-motion with a very high degree of accuracy. This machine provides a convenient and highly accurate method of calibrating accelerometers in terms of known fundamentals and, in combination with a method for inter-comparing different instruments under simulated road-conditions, it enables instrument calibration throughout the entire range of vibrations caused by road irregularities.

J. W. White

Walter C. Keys

Time Element Is Important

In the discussion that followed, W. G. Wall, consulting engineer, Indianapolis, stated his belief that the time of oscillation is the most important factor in the easy riding of a vehicle, and that it is more important than the amplitude of the vibration. As he said, if the time is very slow the passenger stays on the seat and, if the time is fast, the passenger is thrown off the seat even though the amplitude of the vibration is rather small. He asked whether a relation should exist between the time of oscillation of the vehicle spring and that of the cushion spring. To this Mr. Keys replied that he had determined frequencies of 90 to 100 vibrations per min. for a cushion spring and had found such frequencies satisfactory. In general, Mr. Keys continued, the period of vibration on the cushion spring should not be in step with the period of the vehicle on the chassis springs. As to Mr. Wall's query regarding the use of friction to modify the natural period of vibration of the cushion spring, Mr. Keys mentioned the use of a restriction in the air-valve in the cushion spring and said that he found this very useful. The period with the bottom of the cushion spring entirely open is much quicker, the throw is much more violent, and it is necessary to use stiffer cushion springs than would be

R. W. Brown and His Collection of Instruments for Measuring Riding-Comfort
A 10-Element Contact Accelerometer, the Recording Chronograph and Other Interesting Devices for Indicating How Smoothly a Car Rides Were Exhibited by This Representative of the Firestone Company

the case if a smaller opening is provided through which the air can pass.

M. C. Horine, sales promotion engineer of the International Motor Co., New York City, mentioned that in nearly all the investigations on the subject he noted that they are based on what he termed "positive" obstructions. In his own experience he had found that a "negative" obstruction produces a very different effect from that produced by a bump in the road. He asked whether various rebound types of shock eliminator have an effect on that type of road irregularity. In reply, Mr. Keys said that in a touring trip of 100 miles his sensations, with eyes closed, were those of falling into the cushion spring whether the car passed over an obstruction or dropped into a depression.

Other Data on Testing Layouts

Concerning the testing set-up he described, Mr. Brown stated that the vehicle wheel drives the drum. The arrangement is such that a chassis can be removed and another substituted on the drum with the minimum effort. In this manner any commercial vehicle or passenger car can be mounted, the testing instruments attached and readings taken. A relatively large drum is needed to permit sufficient time to elapse so that the vibrations will die out before the obstruction passes around the drum and comes again under the tire.

It was brought out by W. D. Seed, of the International Motor Co., that this company also uses a type of accelerometer which produces a graphical record and that, from this, on a small scale, the period and the amount of the acceleration due to gravity can be measured. It consists of an instrument with a very high period and with an optical attachment. At the same time that the accelerations are measured, a position recorder measures the displacement of the axle with relation to the body of the vehicle. The measurements are made over standard bumps at certain speeds. This gives a direct comparison when springs are changed and also a good physical record of the experiments that have been carried out without relying primarily on the impressions of the observer.

MEMBERS PHOTOGRAPHED FROM THE AIR

McCook Field Army Airplane Makes and Drops Picture of Letter Formation

How the Society members appear when looked down on at a Summer Meeting is illustrated by the picture of them which was taken on Wednesday afternoon, June 2, from an Air Service airplane that flew from McCook Field, Dayton, Ohio, especially for the purpose. The picture was made with special photographic apparatus developed by the Engineering Division of the Air Service for the purpose of exposing, developing and finishing photographs in the airplane while in flight and dropping the print within a few minutes after exposure of the film.

This first public demonstration before a large assembly of the Army's new quick photography apparatus was highly successful and while the airplane was winging its way back to Dayton a lantern slide of the picture dropped at French Lick Springs was made for exhibition at the evening session of the meeting and then the picture was posted on the bulletin board in the hotel lobby.

The weather was ideal for the occasion, sunny, warm and with a gentle breeze blowing. Members turned out in large numbers to form the initial letters of the Society, which had been marked out in white on the golf links. The letter A was outlined by ladies only, while men formed the two end letters. All wore white paper caps and the majority were dressed in white or light-colored clothes. Under the direction of a chief of staff, a chief assembly officer and three squad captains the members were assembled into groups in the shade of the trees in accordance with lettered buttons that had been distributed at luncheon by the button brigade. Each group was then formed into its proper letter upon signal from the bomber and announcer that the airplane was approaching. A liaison officer in Dayton and one at

Part of the Personnel That Made the Airplane Photograph a Success

The Signal Corps for This Event Was Composed of Edge Austin, F. M. Young, O. C. Berry, and Harry Figgie, Who Are Standing in the Order Named, Reading from Left to Right

How the Society's Initials Appeared from the Ground

The Members and Guests Arranged To Form S A E on the Golf Course. A View of the Formation as Seen from the Air by an Air Service Aerial Camera Is Reproduced on P. 529

LOOKING AT THE AIRPLANE PHOTOGRAPH
From Left to Right, Dr. S. M. Burka Who Took the Picture, Lieut. G. W. Goddard Who Piloted the Airplane and Meetings Manager J. A. C. Warner to Whom the First Print Was Delivered by Parachute

French Lick Springs maintained contact to coordinate the letter formation with the arrival of the airplane.

After circling the locale several times, dropping lower each time, the exposure was made and a bunch of fluttering leaflets was thrown out as a signal for the breaking-up of the letter formation. The plane continued its elliptical flight for some minutes longer and then threw out the picture, which descended from a height of more than 1000 ft. and struck the ground within a dozen feet of the flagman waiting to receive it. Cards had been distributed previously upon which members were asked to register their guesses as to the height above ground of the airplane at the time of taking the picture, the nearest guesser to the exact altitude to receive a prize.

The picture was taken at 3:15 p. m., and by 3:30 the airplane was off on the return trip to Dayton, where duplicate prints were to be made and rushed by Air Mail to leading newspapers from the Atlantic to the Pacific coast.

The demonstration was arranged through the courtesy of Major J. F. Curry, commanding officer at McCook Field, who assigned Lieut. G. W. Goddard, chief of the aerial photographic branch of the Engineering Division of the Air Service, to pilot the airplane, and Dr. S. M. Burka, physicist of the photographic branch, to take care of the photographic work.

To the efficient work of the ground organization and the willing cooperation of the members of the Society and their guests is due the creditable pictorial effect produced by the letters.

HOW HIGH IS HIGH?

Members Estimate Altitude of Photographic Airplane at French Lick Springs

Unusual interest was shown in the Altitude Guessing Contest; about 450 members estimated the altitude of the photographic airplane and the estimates ranged from around 225 ft. to 6333 ft.

The altitude reported by the airmen was 507 ft., 6½ in. Miss Peg Hendrickson, Mrs. J. Brandenberg and F. M. Young estimated the altitude at 500 ft. and consequently were asked to guess again. In the second estimates Miss Hendrickson won first prize, F. M. Young annexed the second, and Mrs. J. Brandenberg took the third. Others, whose estimates were near the correct altitude, were C. F. Rauen, R. J. Nightingale, R. R. Keith, M. Winchester, H. R. Roffmann, F. Jehle, M. P. Rumney, C. M. Manly and J. O. Eisinger.

McMILLAN STILL A 10-SEC. MAN

McMillan and Jones Win the Three-Legged Race for the Second Time

The annual field and track events were held on Wednesday afternoon immediately following the airplane-photographic exhibition, the field being laid out on the fairway of the 18th hole on the Valley Course. As usual the 50-yd. dashes held the greatest interest and as usual Neil McMillan led the field by 5 yd. in the 50-yd. dash for men from 30 to 40 years old, thus winning this event for the fifth consecutive time.

R. E. Wilson won first place in the fatman's race, having graduated this year into the "3 lb. per in. of height" class, with T. V. Buckwalter capturing second place and Rollin Abell running third. Charles Marcus again was able to distance all comers in the shot-put.

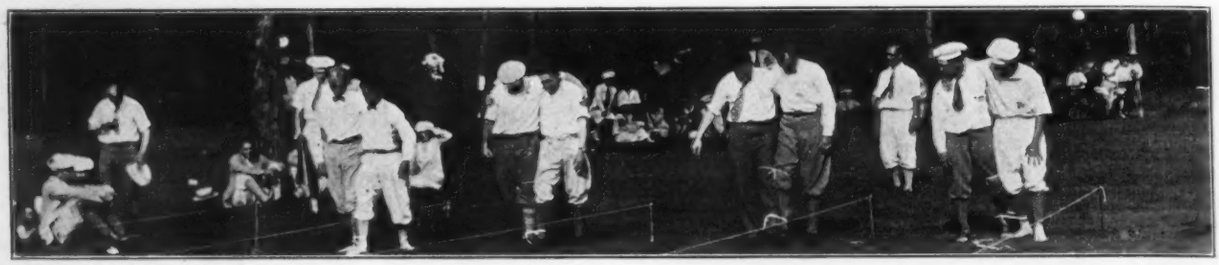
G. T. MOORE, WINNER OF THE BROAD JUMP, MAKING A LANDING

The complete list of the events and those winning places in each are given in the accompanying summary.

TRACK EVENTS

50-Yd. Dash (Men under 30)—First, Norman G. Shidle; second, Ralph Hulton; third, J. R. Bartholomew
50-Yd. Dash (Men 30 to 40)—First, Neil McMillan; second, G. T. Moore; third, Olney Jones
50-Yd. Dash (Men over 40)—First, J. C. Talcott; second, Charles Marcus; third, R. R. Matthews
50-Yd. Dash (Ladies)—First, Mrs. Ernest Dickey; second, Mrs. H. D. Hukill; third, Mrs. W. A. Gross
Fatman's Race—First, R. E. Wilson; second, T. V. Buckwalter; third, Rollin Abell
Three-Legged Race—First, Neil McMillan and Olney Jones; second, L. C. Porter and G. W. Gaidzik; third, J. R. Bartholomew and J. J. McElroy
Potato Race (Men under 40)—First, Olney Jones; second, H. D. Hukill; third, L. C. Porter
Potato Race (Men over 40)—First, J. C. Talcott; second, G. W. Gaidzik; third, J. G. Swain
Potato Race (Ladies)—First, Mrs. Ernest Dickey; second, Mrs. H. D. Hukill; third, Mrs. Paul Roche
Bean Race (Ladies)—First, Mrs. E. R. Jackson; second, Mrs. Ernest Dickey; third, Mrs. Lon R. Smith
Egg Race (Ladies)—First, Mrs. H. W. Simpson; second, Mrs. W. A. Gross; third, Mrs. Paul Roche
Needle-and-Thread Race (Ladies)—First, Mrs. H. W. Simpson; second, Mrs. Charles Hollerith; third, Mrs. Ernest Dickey
Inter-Sectional Relay Race—First, Detroit; second, Chicago

"CROSSING THE BAR"
One of the Contestants in the High Jump Performs the Feat Easily



THE THREE-LEGGED RACE FOR MEN
Niel McMillan and Olney Jones Were the Winning Pair in This Contest

THE LADIES' POTATO RACE
Mrs. Ernest Dickey Proved Herself the Best Collector of "Spuds" and the Fastest Sprinter

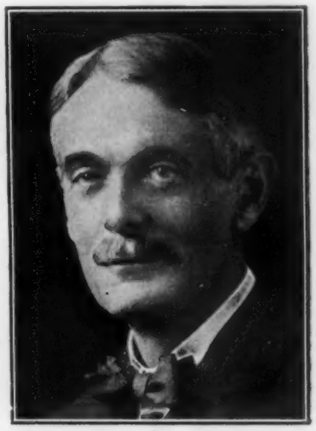
CONTESTANTS IN THE MEN'S POTATO RACE LINED UP FOR THE START

SHORTY MCMILLAN WINS
For the Fifth Consecutive Time This Sprinter Led the Field Home in the 50-Yd. Dash for Men between 30 and 40

E. C. Crittenden

Karl D. Chambers

R. N. Falge



H. M. Crane

THE CHAIRMAN, TWO OF THE AUTHORS AND A DISCUSSER AT THE HEADLIGHTING SESSION

FIELD EVENTS

Shot Put—First, Charles Marcus; second, Rollin Abell; third, L. C. Porter

Standing Broad Jump (Men under 40)—First, G. T. Moore; second, L. E. Lighton; third, W. F. Rockwell

Standing Broad Jump (Men over 40)—First, F. G. Whittington; second, T. V. Buckwalter; third, R. R. Matthews

High Jump—First, F. G. Whittington; second, J. C. Talcott; third, G. T. Moore

Throwing Baseball (Ladies)—First, Mrs. A. M. Graffis; second, Mrs. Paul Roche; third, Mrs. Ernest Dickey

HEADLIGHTING'S NUMEROUS PHASES

Papers and Demonstrations Summarize Conditions and Indicate Future Practice

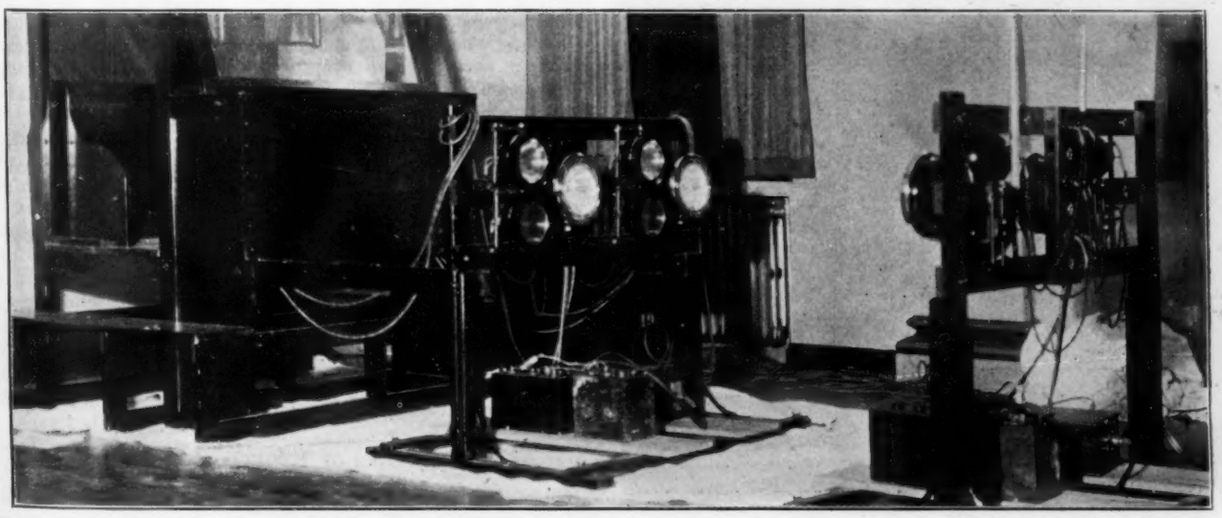
Satisfactory headlighting, that absorbing and baffling problem upon the solution of which so large a measure of safety and of facility in night driving depends, seemed markedly nearer to attainment after all the evidence regarding recently accumulated research-data on head-lamps had been assembled and presented at the Headlighting Session and Demonstrations held on Wednesday evening, June 2. Under the able chairmanship of E. C. Crittenden, the papers and verbal discussions were delivered snappily on scheduled time and ample opportunity for watching the extremely interesting demonstrations that followed was thus afforded the many members who attended this session.

COMPLEMENTARY-COLOR HEADLIGHTING

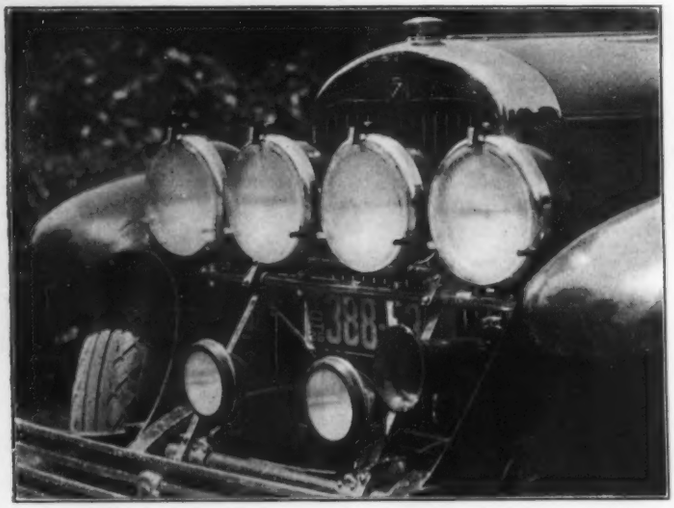
The complementary-color headlighting-system is a method for enabling motor-vehicle head-lamps to illuminate the road and, simultaneously, to enable the drivers to protect their eyes under all conditions from the opposing light-rays of similarly equipped vehicles. Two forms of differentiated light are used, one being allowed to pass freely through a viewing-filter by which the other form of light is almost completely absorbed. In this paper, which is printed in full in this issue of THE JOURNAL, beginning on p. 613, K. D. Chambers presented full details of the system and supplemented it by spectacular demonstrations of the complete equipment that he had installed in the Convention Hall. All who so desired were allowed to view opposing headlights of this system through the viewing-filters in the car that they temporarily were "driving," to manipulate and change the filters and to make their own comparisons and deductions, as well as to fire a barrage of queries at Mr. Chambers concerning details of the advantages claimed for this lighting equipment.

EQUIPMENT FOR HEADLIGHTING INVESTIGATIONS

As stated by R. N. Falge, in charge of automotive lighting for the National Lamp Works, Cleveland, one part of the program on which the joint steering-committee has been working is a symposium of opinion on what constitutes ideal headlighting. A subcommittee was appointed to design and make available facilities that would enable the engineers of motor-car companies to reach a conclusion as to what con-



EQUIPMENT FOR DEMONSTRATING THE COMPLEMENTARY-COLOR HEADLIGHTING SYSTEM
An Observer Seated in the Booth at the Left Could View the Headlights of the Approaching Car at the Right through the Special Filters and Also See How His Own Headlights Were Illuminating the Roadway



ONE OF THE HEADLIGHTING DEMONSTRATION CARS
After the Papers Were Read at the Headlighting Session on Wednesday Evening, a Number of Cars Equipped with Various Forms of Equipment Were Used To Illustrate the Points Brought Out

stitutes desirable practice in light intensity and distribution, taking into account the interest of all users of the highway, and to demonstrate these conclusions. Since headlighting requirements are determined by a large number of factors, each varying greatly, experience with variable headlighting-equipment was needed to suggest the range of beam characteristics to be investigated in meeting the demands of typical difficult situations. Such equipment should make it possible to build-up beams of different depths and vary the relative intensities from top to bottom, to spread out the light through various total angles differing from top to bottom and with variable proportions near the center and at the wider angles; also, it should be able to distribute the light differently to the right and to the left of the car, and alternative lighting should be available for meeting other cars.

Accordingly, seven cars having equipment of the foregoing characteristics were made available by the subcommittee for demonstration following this session. Included were four head-lamps provided with standard parabolic reflectors and incandescent lamps and having a plain cover-glass in the door. The test lenses and masks were arranged to slip into clips on the outside of the door to facilitate changes. Two focusing screws were supplied, one to modify the beam by moving the light source up and down and the other for moving it along the axis of the reflector. The head-lamps could be aimed individually or as a group. A panel was provided with switches, ammeter connections and rheostats for varying the light output from the individual units.

LOYD JONES DEMONSTRATING THE USE OF THE VIEWING FILTER
The Complete Demonstrating Equipment for the Complementary-Color Headlighting System Is Illustrated on P. 543

For lateral distribution of the light, 22 lenses were available having spreads varying in small steps from 6 to 40 deg. For simple vertical spreading six lenses of 2, 3 and 4 deg. were furnished and also some diffusing covers. The focusing adjustments permitted deepening the intensities from top to bottom. Six masks of several forms were available for decreasing the depth of beam and reducing the light output from a head-lamp. To give complete freedom in forming the desired main driving-beam an auxiliary driving-lamp was included to provide, for passing purposes, road illumination of a character acceptable to the approaching driver, the top of the beam from this unit being aimed to intercept the road about 75 ft. ahead. The ammeter connections were arranged so as to permit reading the amount of current through one lamp while the others are burning and then to secure a record of a given set-up. A photometric test made with the units set for the several values of current employed then gives a quantitative record of the light pattern and of the intensity.

BEAM PATTERNS AND LIGHT INTENSITIES

J. H. Hunt, chief of the electrical division of the General Motors Corporation Research Laboratories, drew diagrams of the beam patterns produced by the equipment already described and presented in considerable detail the specific characteristics of the several cars with respect to beam patterns obtainable and the relative light intensities. In conclusion, he said that in the past the types of lighting on motor cars have been determined largely by what the lamp manufacturer has submitted to the car builder. The only method that the car builder had of deciding what type he wished was to take such lamps as were available and make tests. Now, in Mr. Hunt's opinion, the point has been reached where the car builder must specify the beam he considers best, and to do that he must study the beam.

HEADLIGHTING-EQUIPMENT TROUBLES

In speaking on the above subject, A. W. Devine, engineer in charge of the equipment section, Registry of Motor Vehicles, State of Massachusetts, remarked that the headlighting research-program of the Illuminating Engineering Society and of this Society includes a survey of new head-lamp equipment. This survey is being made at present to discover defects in the design and construction of head-lamps and to determine the causes of failure in many cases to secure in service actual results which are in compliance with the intent of the standard specifications for tests of approval for headlighting devices. He based his address on a partial summary of data resulting from this survey.

Saying that the difficulties which have thus far prevented the best results from the system under investigation are inferior head-lamp equipment supplied with the automobile and improper use of the equipment by the operator of the vehicle, Mr. Devine went on to outline how the attention of automotive engineers and of car-builders should be concentrated on details of head-lamp construction in an effort toward improvement and stated, in conclusion, what the car builder can do to remedy the defects of the present situation. First, he should build his present equipment so that proper results will be attained. Second, he should try to acquire the viewpoint of the motor-vehicle administrator, who must deal with the so-called "average" public. Then, the car builder should put lamps on his car such that this average motorist can use them and get proper results. The methods of adjusting the head-lamps must be simple, few in number and designed for accessibility.

POSSIBILITIES OF REDUCED CANDLEPOWER

During the discussion, H. M. Crane commented further on details of beam patterns and called attention to the extremely narrow hot-spot in headlights. He emphasized the need for simplicity and is hopeful that the tests will show power-

ful beams of 40,000 to 50,000 cp. to be unnecessary. Other prominent members participated in the discussion, but their remarks are too voluminous for inclusion in this account. Many members availed themselves of the privilege of riding several miles over hilly roads in the test-cars and observed the performance of the head-lamp test-equipment that was demonstrated.

RACE ENGINE SECRETS TOLD

Duesenberg and Miller Give Details of Their Latest Constructions

Much information not previously divulged about the engines and cars used in the Indianapolis 500-mile race this year was given to members of the Society at the Race Session on Thursday afternoon by the constructors, Fred S. Duesenberg, of Indianapolis, and Harry Miller, of Los Angeles. The session, which lasted 3 hr., was an informal discussion without any prepared papers, in which talks from the platform were made also by Chairman F. E. Moskovics, president of the Stutz Motor Car Co.; Otto C. Rohde, chief engineer of the Champion Spark Plug Co.; Ralph R. Teetor, chief engineer of the Indiana Piston Ring Co.; W. S. Harley, chief engineer of the Harley-Davidson Motor Co.; Thomas Midgley, Jr., vice-president of the Ethyl Gasoline Corporation; W. G. Wall, chairman of the technical committee of the Indianapolis races, and R. W. Brown, research engineer of the Firestone Tire & Rubber Co.

In opening the session, Chairman Moskovics hastily traced the development of racing from the late nineties to the present time. In the first Long Island cup race the only rule was that cars should weigh less than 2240 lb. Practically all the engines had a cylinder bore of more than 7 in. and a stroke of between 4¼ and 4¾ in., with a piston displacement of from 1000 to 1200 cu. in., and developed about 105 hp. The maximum speed was about 95 m.p.h. By contrast, the engines in this year's cars had 91½-cu. in. displacement, weighed 1400 lb. and developed from 125 to 150 hp., and the maximum straightaway speed was 130 m.p.h.

Duesenberg Two-Cycle Supercharged Engine

Mr. Duesenberg displayed blueprints of cross-sections of his eight-cylinder two-cycle engine that has not yet undergone much development but has aroused widespread interest. He explained that the ports are opened and closed by a rotor and that increasing the width of the ports had increased the power. The cylinders have a bore of 2¾ in. and stroke of 2 5/16 in. and the ports extend about one-third of the distance around the cylinders. The intake-port is opened about ¼ in. before the exhaust-port is uncovered and remains open during about one-fourth of the up stroke of the piston, allowing the supercharger to fill the cylinder. Good operation requires about 15 lb. pressure of the supercharger, although the car in the race had only about 9 lb. The spark-plugs remained remarkably cool during the race. Eight piston-rings were broken in the race and tore out little pieces of the pistons so that the hot gases shot down into the crankcase but that did not stop the engine, which Mr. Duesenberg believes is not so delicate as the four-cycle engine. The cooling water enters first around the exhaust-port and then passes around the spark-plug.

Replying to questions, Mr. Duesenberg said that he thinks the supercharger requires from 12 to 15 hp. and a supercharger speed of 27,000 r.p.m. was required to maintain a pressure of 9 lb.; although he has not tried it, he believes that the Roots-type blower would be more satisfactory than the geared type on the two-cycle engine because it is hard to turn the engine over fast enough to get a good start, the engine-speed is controlled by throttle, the compression is 46 or 47 lb. per sq. in. at 4200 r.p.m., and there is practically no supercharger pressure below an engine-speed of 2000 r.p.m. although the engine will run as slow as 1000 r.p.m.

Discussion brought out the fact that the cylinders are fired in pairs. The compression-ratio of 4½ to 1 is much too low. Magneto ignition has not been tried. Spark-advance is about 45 deg. Answering an inquiry by T. J. Litle, Jr., Mr. Duesenberg said that although the absence of valves and other things which commonly cause trouble makes this a desirable type of engine, he does not believe that the high-speed racing type of engine will be used for passenger-car service but if valves and valve mechanism can be brought to some approach to racing-engine design the speed of the phaeton can be increased between 25 and 30 per cent and the engine will be more efficient.

Fred Duesenberg

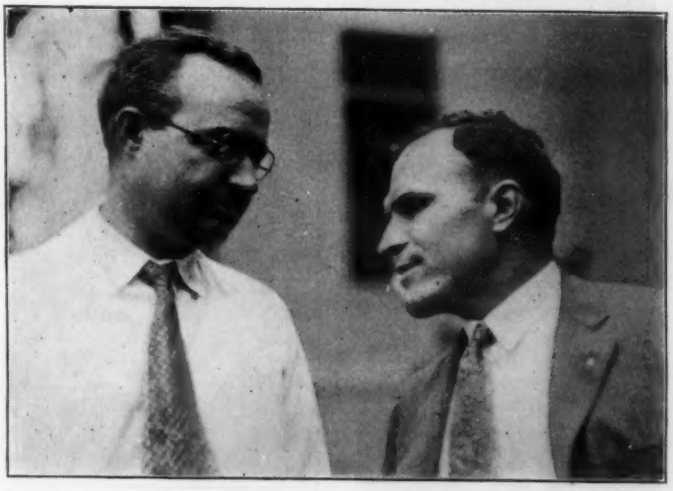
Harry Miller

The Two Chief Speakers at the Race Session

Interest in Miller Front-Drive

When Mr. Miller took the platform the interest centered largely in the front-end drive and supercharging of the Miller cars, but many other details were brought out in the questions and answers. These engines are of eight-cylinder four-cycle type, with 2 3/16 x 3-in. cylinders and a compression-ratio, supercharged, of 5.35 to 1.00. At their maximum speed of 7000 r.p.m., the engines develop 154 hp. A car-speed of 130.8 m.p.h. has been attained on the board track at Los Angeles with an engine-speed of 6400 r.p.m. The crankshaft is made as two four-throw shafts twisted in the middle and no other type has been tried. Originally the crankshaft problem was one of carburetion, said Mr. Miller, but supercharging may correct this trouble.

The supercharger is geared to the crankshaft in front of the flywheel through an intermediate gear and, at an engine-speed of 7000 r.p.m., the peripheral speed of the tips of the blades is 68,533 ft. per sec., or 720 m.p.h. This gives a pressure of 16½ lb. The diameter is 7 in. and the 3-in. central



Two of the Participants in the Discussion at the Race Session
Thomas Midgley at the Left and Ralph R. Teetor at the Right

bucket is made of duralumin. The fan blades are of drawn vanadium steel. From 18 to 20 hp. is required to drive the supercharger at maximum engine-speed.

Regarding the front-end drive, Mr. Miller said that he thought this type has many possibilities, as it pulls the car instead of pushing it, permits the body to be placed as low as desired, is easy to drive, steers very easily without any need of oversteering, and has all the mechanism at the front where it is accessible.

As much of the car weight as possible is placed on the front wheels; all that is carried on the rear is the fuel tank, and the rear axle weighs only about 26 lb. The unsprung weight on the front axle is only about 20 lb. more than it would be with conventional construction. The transmission is carried by the frame and a bent axle goes around it. The brakes are on the transmission instead of on the wheels. The front wheels have no tendency to shimmy if they are balanced. The universal-joints rotate at wheel speed instead of engine-speed and the extreme up-and-down movement is only about 1½ in. On the turning radius four ball-bearings are used in each joint. On the racing cars the steering angle is about 30 deg. although never more than 3 or 4 deg. is used in making the track turns.

An interesting point mentioned by Mr. Miller is that the new small supercharged engines do not slow-down when the accelerator is released as quickly as the larger engines; therefore less stress is felt by the supercharger in slowing down.

RECENT FUELS AND LUBRICANTS DATA

Engine Wear and Corrosion, Formation of Carbon and Fuel-Volatility Analyzed

Differentiation between wear and corrosion in engines by data obtained from analyses of lubricating oils used therein, a report of the work to date on the measurement of fuel-volatility according to the cooperative fuel-research program and a specific analysis of carbon-deposit causation were main features of the Fuels and Lubrication Session that was held on Thursday afternoon, June 3, at which three papers were presented. H. C. Mougey, chief chemist of the General Motors Corporation Research Laboratories, Detroit, was chairman. During the progress of this debate, massed data on the respective subjects were presented which held the interest of the many members present and enticed them into prolonged discussion of these important matters.

Engine Wear or Engine Corrosion?

In connection with the paper on Causes of Wear and Corrosion in Engines, by O. M. Burkhardt, research manager of the Society, it is perhaps well to state that, early in 1925, the Society undertook to organize researches on contaminated crankcase-oil. Arrangements were made with eight car and truck builders to have each of them select six to eight service stations located in cities that best represent the various atmospheric and geographical conditions of the Country. Localities from which complaints of engine depreciation were known to have come to many car and truck builders were included. These carefully selected service-stations were then approached with the request to cooperate in the collection of samples of contaminated crankcase-oil, and the samples so collected were sent to the Bureau of Standards for analysis. The various determinations made in this analysis were presented by Mr. Burkhardt in his paper, together with his interpretations of these data.

Since it is well known that the medical profession studies the symptoms and causes of disease from ingredients derived from the blood and from substances taken from the human body, the thought was expressed by Mr. Burkhardt that it may be feasible to study in a similar manner, from the ingredients found in the oil, certain indications as to what has taken place with regard to wear and corrosion in the engine that was lubricated by the oil under consideration. Inasmuch as the percentages of harmful ingredients found are necessarily very small, it is important that the analysis of the oil be very accurate and that conclusions be drawn with extreme care. Having this very accurate information available from a fair number of samples, Mr. Burkhardt used it to diagnose the various causes of wear and corrosion.

In the analysis of the oil samples, all the iron was reduced to iron oxide. This procedure made it necessary to study certain axiomatic relations to one another of the various ingredients found in the ash. Some of these relations are that wear is a function of the silica, the viscosity, the amount of abraded metal-particles, and the number of starts, so that starting frequently involves the rubbing of dry and partly corroded surfaces; and that corrosion is a function of water, the sulphur content of the fuel, intermittent running, and time. In addition to the diagnoses, Mr. Burkhardt showed a number of graphical representations illustrating the effect that various factors and conditions have on the contamination of oil and, consequently, on the wear and the corrosion that bring about depreciation of motor-vehicle engines.

Mileage, Engine Condition and Other Factors

In response to a query from Chairman Mougey, as to how often the lubricating oil should be changed, Mr. Burkhardt said that mileage as an indication is unsatisfactory because as the engine continues to run it accumulates silica and that this and the other factors such as corrosion interfere greatly in using the speedometer as an indicator of when to change the oil. It was suggested by J. F. Winchester, supervisor of motor equipment for the Standard Oil Company of New Jersey, that the Society continue the research but that engine condition should be taken into account in the future and

H. C. Mougey

Samuel P. Marley

C. J. Livingstone

W. A. Gruse

The Chairman of the Fuels and Lubrication Session and the Three Authors of One of the Papers

W. R. Strickland

O. C. Berry

G. A. Round

B. B. Bachman

FOUR OF THOSE WHO TOOK PART IN THE DISCUSSION AT THE FUELS AND LUBRICATION SESSION

that the lines of activity be changed to include the operators of large fleets who would cooperate by furnishing the samples, since they are equipped to furnish additional needed data and to supervise the obtaining of the samples. W. R. Strickland, of the Cadillac Motor Car Co., outlined the experience of his company in regard to the matters under discussion, saying that the conclusions it had reached are borne out by the summary presented in Mr. Burkhardt's paper. As to contamination, he said that if a cleaner is attached to remove dirt from the oil, his company considers it safe to advise its customers to change oil every 2000 miles.

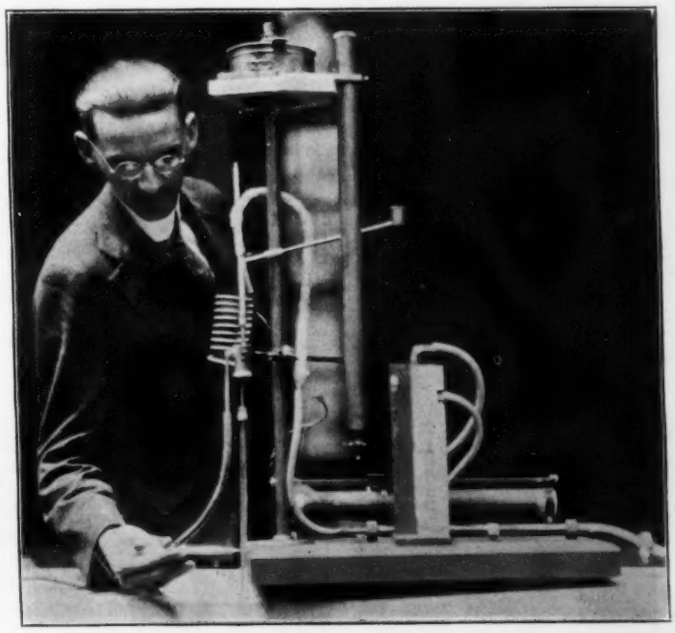
Mr. Burkhardt replied to Mr. Winchester's remarks by admitting the desirability of studying the subject far more intimately but enumerated some of the many handicaps and difficulties that must be overcome before this can be accomplished. He reiterated his statement of the effort made to distinguish between wear caused by abrasion and that caused by corrosion, since no samples distinctive of wear alone or of corrosion alone are available. G. A. Round, of the Vacuum Oil Co., said that he does not fully agree with Mr. Winchester's suggestion that samples be sent in from fleets alone, because these are carefully supervised and do not represent what the average driver encounters; rather, he would have samples taken from the field under as widely varied conditions as possible. In two separate sets of tests, Mr. Round said that with high sulphur-content in the fuel he had found indication of corrosion even in an engine that was running hot enough to eliminate any water in the crankcase, and that these results checked. B. B. Bachman, engineer for the Autocar Co., supported Mr. Winchester's suggestions but believed that the data collected in collaboration with organizations which have the better facilities can be used to constitute an alternate set of data and conclusions, enabling comparisons of the relative value of devices when used by individuals and when used under organized, systematic supervision. He emphasized that the tendency in combating the evils with which automotive engineers have been faced in recent years has been toward an increased complication of the mechanisms that are employed.

VOLATILITY OF AUTOMOBILE FUELS

In presenting his paper on this subject, T. S. Sligh, Jr., physicist, Bureau of Standards, explained that volatility is considered to be measured by the quantity of fuel that will be evaporated under equilibrium conditions into a definite space at definite temperature. This is proportional to the vapor density of the fuel. The volumes occupied by given weights of air under a pressure of 1 atmosphere are taken as a convenient measure of vapor space. The paper presents a brief statement of some fundamental principles relating to evaporation of mixtures and discusses briefly the previous work on fuel volatility.

Mr. Sligh described a dynamic volatility method involving measurement of the percentage of the fuel that is evaporated under equilibrium conditions in some definite mixture of air and fuel and discussed the theoretical aspects of such measurements. Data were presented for a limited number of fuels showing the general characteristics of this type of distillation as compared with the Engler type. The effects of variations in compositions as affecting starting volatility and operating volatility were shown. Continuing, he said that while the relative volatility characteristics of fuels under conditions existing in the engine are shown by this air distillation, precise prediction as to the performance of such fuels in any particular engine is influenced largely by engine characteristics, especially as regards the attainment of vapor equilibrium. Consequently, such predictions are limited by the assumptions regarding operating conditions.

After complimenting Mr. Sligh and the Bureau of Standards on the work represented by the paper, O. C. Berry, chief engineer of the Wheeler-Schebler Carburetor Co., entered the discussion by remarking the great value its data have to the refiner and to the designer of carbureters and manifolds. He mentioned also how highly desirable it is that engines operate on one fuel only and depend for starting on a richer mixture of this single fuel than is needed after warming-up. Mr. Berry feels that Mr. Sligh's figures on richness of mixture desirable for starting an engine are perhaps optimistic. He referred to the habitual consideration of the carbureter manufacturer as being helpless in deter-



HOW VOLATILE IS YOUR GASOLINE?
T. S. Sligh, Jr., Can Tell You the Answer with the Aid of the Apparatus Shown

mining the temperature at which the engine should be started A'so, he emphasized the importance of the very low end of the curve for the fuel that is distributed generally throughout the United States. He said further that the carbureter and manifold designer is not interested so much in the end-point of the fuel as in the middle range and has the greatest interest in the lower end of the curve. Mr. Berry also recommended that, in the future, refiners make a much more marked distinction between gasoline suited for summer use and gasoline suitable for winter.

Formation of Carbon Deposits

The paper on the Influence of Temperature, Fuel and Lubricant on Forming Engine Carbon-Deposits was by W. A. Gruse, C. J. Livingstone and S. P. Marley. It is printed in full in this issue of The Journal, beginning on p. 607.

At the opening of the discussion, G. A. Round exhibited several lantern slides of photographs showing carbon deposits in a six-cylinder engine to illustrate that other factors than those already mentioned have an even greater effect in forming carbon. He thinks that the character of the deposit, as well as the quantity, is very important. Neil MacCoull sees no particular interest in knowing the actual weight of the carbon deposit. He mentioned the likelihood of different carbon formations which, for the same weight, may have a different effect on detonation; that is, a very soft spongy carbon, well covered over the piston-head, may not have the same effect as a flaky dry carbon, when the edges of the flakes become incandescent due to heat. R. F. Kohr regretted that leaner mixtures than 12 to 1 were not included in the paper. Quoting the Bureau of Mines to the effect that the average automobile on the road uses mixtures between 7 to 1 and 9 to 1, Mr. Marley answered that, in comparison, a 12 to 1 mixture *is* a lean mixture. In reply to some of Mr. Round's remarks, Mr. Gruse said that he thinks too much emphasis should not be placed on the source of lubricating oil at present. Further discussion included the effects of oil viscosity, performance as regards oil consumption and related topics. In conclusion, Chairman Mougey said that recent tests he had made varied from 3000 miles per gal. at 20 m.p.h. to about 500 miles per gal. at 50 m.p.h., indicating that the automotive engineer must provide enough lubrication at low speeds but that, under those conditions, too much is provided at high speeds.

NEW COOLING MIXTURES STIR INTEREST

Discussion Following H. K. Cummings's Paper Centers on Glycerine and Glycol

Ethylene glycol and glycerine, because of their recent commercial exploitation, were the cooling materials chiefly featured in the discussion at the Anti-Freeze Session on Thursday evening. H. K. Cummings, in his paper, Anti-Freeze Solutions and Compounds, stressed the advantages of the low freezing and high boiling points possessed by both liquids. A higher first cost, as compared with that of alcohol, is a common disadvantage, offset to some extent by long serviceability. Glycerine was said to have the additional deterrent to its use for radiator cooling of high viscosity at low temperatures. The possible injurious action on rubber of glycerine that was not distilled or free from electrolytes was also mentioned.

J. F. Winchester

H. K. Cummings

The Chairman and the Author at the Anti-Freeze Session

G. A. Round, commenting in a prepared discussion on the use of ethylene glycol in a cooling mixture, explained the apparent tendency of this substance as well as glycerine to cause leakage in rubber gaskets and hose connections. He told of experiments tending to show that immersion in glycol decreases the elasticity and tensile-strength of rubber less than does immersion in water. Leakage in cooling systems where a glycol solution is used subsequent to water was traced to the withdrawing by the glycol of water previously absorbed by the rubber. Due to this action of the glycol, the hose and gaskets collapse to a certain extent. The consideration leading to this conclusion is the loss in weight of the rubber upon being subjected to glycol after immersion in water.

As a remedy Mr. Round recommended that, in the case of cars operated by the layman, all rubber gaskets and hose be renewed when the change-over is made from pure water to a glycerine or glycol mixture. For well-supervised commercial fleets, he thought that tightening and carefully watching connections would probably assure satisfactory operation. Another suggestion made for dealing with leakages was that about 1 pt. of heavy lubricating oil be placed on top of the water when it is being drained from the crankcase prior to refilling the radiator with a glycol or glycerine mixture. The oil should be allowed to ride the surface of the water as the radiator is emptied, and then as much of it as conveniently can be permitted to run out. Apparently the oil-film left inside the hose prevents the glycerine or glycol from penetrating minute pinhole leaks and also coagulates rust particles lodged in the small apertures, thus forming a further preventive barrier against leakage.

A topic brought up by J. F. Winchester was the advisability of furnishing hydrometers with glycerine and glycol solutions, so that the public might ascertain exactly what mixtures were being placed in their radiators. Other points discussed were the utilization of petroleum products for engine-cooling and the differing conditions under which the various types of anti-freeze material are most advisedly used.

Briefly summarized, Mr. Cummings's paper outlined some of the factors influencing the choice of a radiator liquid, considered the merits of various types of cooling solution and described methods of testing anti-freeze preparations.

In introducing the speaker, Chairman J. F. Winchester warmly praised the work of the Bureau of Standards, of which Mr. Cummings is a representative.

WHAT DID THE SECTIONS DO?

Lively Stunts That Included a Little Bit of Everything and All of It Good

The well-balanced ration of technical sessions and sports activities, provided by the Meetings Committee at the Summer Meeting, was seasoned by the entertaining stunts that were staged by several of the Sections. These events being of a wide variety added a delightful sprinkling of the spice of life to the already interesting character of the activities of the Summer Meeting.

Milady's Fan

A dainty feather fan was the gift of the Metropolitan Section to each lady. Every fan had attached to it a tag bearing a number that gave the owner of the fan a chance to win one of three beautiful prizes when the lucky numbers

were drawn during the dancing on Tuesday evening. The prizes were won by Mrs. E. R. Jackson, Mrs. Moore Kelly and Mrs. C. C. Carlton.

Cleveland's Head-Waiter

The Cleveland Section, without any announcement of their intention, installed in the hotel dining-room for Wednesday dinner a new head-water who had ideas of his own with regard to his duties as superintendent of service. His excessive zeal in ushering guests to their places in the dining-room, his officiousness toward others after they were seated and his irascibility toward those who were seen to laugh at him attracted the attention of everyone. His manners became worse as the dinner progressed, and it caused little surprise when a prominent member became engaged in a quarrel with him which resulted in the ejection of the head-waiter from the dining-room by this member. The real surprise came a moment later when the ejector brought his antagonist back into the dining-room and introduced him as Luke Barnett, inimitable presenter of a unique act.

Dayton Presents Air-Photos

The Dayton Section gratified the wishes of the many people who, upon looking at the print of the airplane photograph of the Society's initials which was taken on Wednesday afternoon, wondered how they could obtain a print to take home. Extra prints were made at Dayton, and Lieutenant Goddard and Dr. Burka flew to French Lick Springs on Thursday afternoon and brought as a gift from the Dayton Section a supply of prints for distribution. The necessary arrangements at Dayton were directed by R. Insley who received the cooperation of other members of the Dayton Section. F. W. Heckert, J. M. Miller and F. G. Shoemaker, all from McCook Field, Dayton, were the guiding geniuses at French Lick Springs.

Collecting Prizes Was Her Specialty
Mrs. E. R. Jackson, Winner of the Metropolitan Section's Prize Bag, Shown in the Illustration, and a Number of Other Prizes

Detroit's Famous "High Hat" Band
Phil Overman, H. A. Hansen, L. C. Hill, and E. V. Rippingille Discoursed Sweet Strains at Mealtimes and on Other Occasions

Chicago Favors Ladies

When the ladies went to the Grand Ball on Thursday evening, each one wore a beautiful corsage bouquet, the gift of the Chicago Section, which for 2 years has shown this delightful attention to the ladies present at the Summer Meeting.

Spectacular and Thrilling

A cleverly-conceived and skillfully-executed stunt was that of the Indiana Section, whose members assembled on the stage at the opening of the Grand Ball and gave the audience several thrills a minute through the medium of a dramatic presentation under the title of Pluto Vanities of 1926. Among those actively and vociferously present were O. C. Berry, G. T. Briggs, W. S. Harley, Thomas Midgley, Jr., F. E. Moskovics and C. A. Musselman. The crowning feature of this act, which purported to be a party of theatrical personages, involved the wheeling in of a bathtub into which plunged a young person, Bert Kelly, who had disrobed under shelter of a brilliant shawl. Upon emerging from the tub the bather was apparently overcome by shame and wept while singing a pathetic ballad, during the rendition of which a burly policeman, A. W. Herrington, fought his way through the crowd and raided the party.

High Hats Score Hit

The Detroit "high hats" presented their stunt later in the evening. The members of the Detroit Section, wearing tall red-paper hats, gave to each lady dancing with them a ticket bearing a number. When each "high hat" had given away five tickets, he retired from the dancing. After dance, numbers were drawn and prizes given to Mrs. E. R. Jackson, Mrs. W. J. Cummings and Mrs. O. C. Berry. Expectancy for this event had been aroused since Tuesday at luncheon when a group of Detroit troubadours and warblers, ably led by Clayton Hill of the seraphic countenance, who sat on a sort of perambulator and presided at a melodeon, made their way through the lobby and the dining-room, discoursing

sweet strains. Phil Overman, who inspired this minstrelsy, was present with voice and banjo, and the other two strolling musicians in the group were H. A. Hansen and E. V. Rippingille. This procedure, repeated at subsequent meals, was a fitting prelude to the event of Thursday evening.

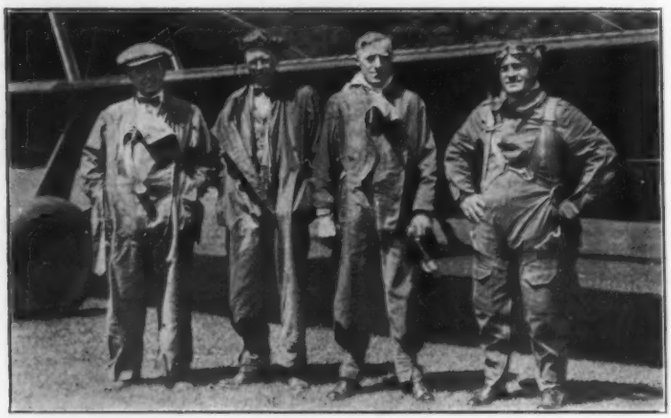
The Grand Ball

Thursday evening after 10 o'clock was given over to the Grand Ball which lasted merrily until dawn or thereabouts. If joyful faces can be taken as indicative of the feelings of those who participated in this event, it is safe to say that the Grand Ball was a superlatively pleasurable occasion.

DAYTON COMES FROM ON HIGH

Lieutenant Bertrandias Brings Section Members in an Army Airplane

More than fitting and thrilling was the arrival of the Dayton Section contingent on Tuesday afternoon in a United States Army Douglas Transport airplane from McCook Field. Piloted by Lieut. V. E. Bertrandias, one of the Army's best



The Airplane Quartet from Dayton

flyers, the plane brought F. W. Heckert, J. M. Miller, J. Rauen, and F. G. Shoemaker. The airmen were greeted with great enthusiasm, despite the fact that several golf fiends had to delay a drive or two while a very skillful landing was effected on the golf course.

The airplane was the object of great interest to many spectators. The take-off was made on Thursday afternoon.

IMPETUS GIVEN TO SOCIETY'S RESEARCH

Many Details Settled at and Much Inspiration Drawn from Well-Attended Meeting

The well-attended luncheon-meeting of the Research Committee held on Wednesday was fruitful in two directions: practical, concrete progress in the Society's research projects was made, and inspiration was obtained from the broad-gaged, clear-visioned discussion of the nature and function of research.

J. O. Eisinger, of the Bureau of Standards, described the Cooperative Fuel Research that has been carried on since the Annual Meeting. A study is now to be made of the effect on warming-up and acceleration of varying certain points on the lower part of the fuel-distillation curve and the influence of the 50-per cent point on engine-performance. The fuels for this investigation have been made up, according to a report presented on behalf of the subcommittee to which this work had been assigned.

At its last meeting, the Cooperative Fuel Research Steering Committee recommended that the Society arrange for the presentation, at the next Annual Meeting, of a sym-

Dr. H. C. Dickinson

J. O. Eisinger

posium on the economic and engineering aspects of the detonation problem. Following out this line of action, the Research Committee authorized Chairman Dickinson to appoint a sub-committee to supervise the preparation of a summary report of the experimental results so far obtained on the effects of detonation.

Discussion on the contaminated crankcase-oil research was confined to the necessity for defining clearly to the engineering public the purpose underlying the investigation just ended. Emphasis was laid on the fact that this survey was intended to reveal what actually was found in the crankcases of cars operating under different conditions throughout the Country. As a cooperative project of engineering societies, it had a breadth of scope unobtainable in the work of any individual commercial organization. The belief was expressed that it constituted a valuable statistical study.

Highway research has for some time been centered on the cooperative motor-truck impact-tests carried on at the Bureau of Public Roads. One of the Research Committee's contributions to this work was a short treatise on instrumentation prepared by Dr. Benjamin Liebowitz and presented by Dr. Dickinson in the form of a discussion to James A. Buchanan's paper at the Tire and Rim Session of the Summer Meeting.

R. W. Brown paid a tribute to the value of the Research Committee's activities in the field of riding-qualities, which have taken the form of arousing interest and disseminating information on this subject. He said that the interest shown at the last meeting of the Riding-Qualities Subcommittee had given a decided impetus to his development work on the contact-type of accelerometer, and had stimulated him to more rapid progress.

While the Society's research on headlighting was discussed to some extent by the Research Committee, it was more extensively dealt with at the breakfast-meeting of the Joint Steering Committee on Headlight Research of the Illuminating Engineering Society and this Society on Thursday morning. It was there voted to disseminate among car builders a report already prepared on lamp construction. The Joint Committee also approved the Proposed Specifications for Head-Lamp Construction drawn up by the Lighting Division of the Society's Standards Committee.

NEW FINAL-DRIVE GEARS FOR CARS

Hypoid and Underslung Worm Developed for Low-Hung Chassis and Silence

Two new forms of gear for rear-axle work on passenger cars were shown in lantern slides and their design, production and advantages were explained at the Gear Session on Friday morning by A. L. Stewart and Ernest Wildhaber, of the Gleason Works, and L. R. Buckendale, of the Timken-Detroit Axle Co. Both types of drive have been developed to meet the demand for cars having a low center of gravity,

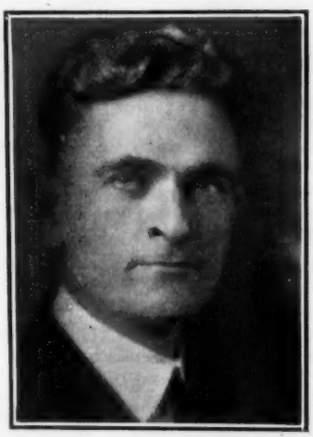
high speed and silent operation. The pinion in the hypoid drive and the worm in the new worm drive are placed below the axis of the driven gear. This lowers the propeller-shaft, dispenses with the rise in the car floor under the rear seat and, in general, permits of a lower chassis and body top.

The hypoid gear and pinion is a modification of the spiral-bevel-gear drive and possesses some of the characteristics of the worm drive, such as sliding tooth-contact, silent operation, axis of the driving member either below or above the axis of the driven gear, and great durability. Another distinct advantage of this type as compared with the straight-bevel and spiral-bevel gear is that the pinion is considerably larger for the same gear-ratio and is therefore stronger, hence both the pinion and gear can be made smaller for the transmission of the same amount of torque. The teeth of the hypoid ring gear can be formed on machines that are now used for the production of spiral-bevel gears and the pinions can be made on modified machines. The new hypoid gears and the process of forming the teeth are covered by patents owned by the Gleason Works.

The paper by Messrs. Stewart and Wildhaber and also that by Mr. Buckendale are printed in full elsewhere in this issue of THE JOURNAL.

PASSENGER-CAR UNDERSLUNG WORM-DRIVE

The new worm drive for passenger-car use differs from the conventional motor-truck worm drive chiefly in having the worm underneath instead of above the worm gear. This type has been in successful use on low-hung motorcoaches for some time, notably in dual form for the two-motor drive



Photograph by Bachrach

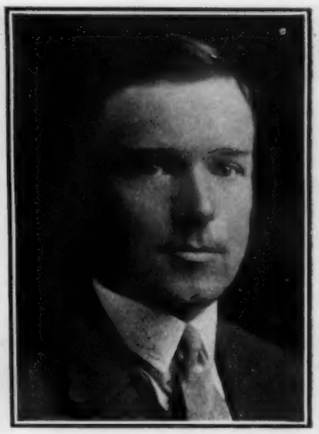
C. D. McCall L. R. Buckendale

THE CHAIRMAN OF THE GEAR SESSION AND THE AUTHOR OF THE PAPER ON THE WORM DRIVE

on the gasoline-electric motorcoaches operated by the Philadelphia Rural Transit Co. Mr. Buckendale traced the development of the worm drive briefly since 1917, and its adaptation to motor trucks, fast motorcoaches and lastly to private passenger-cars.

In the discussion on the hypoid gears, replying to a question by Chairman C. D. McCall, Mr. Stewart said that no modification of tooth design has been made. In a pair of gears of 13 and 61 teeth, with a 12-in. pitch-diameter and 2-in. offset pinion, the pinion diameter is 0.4 in. larger than that of the spiral-bevel pinion of a corresponding set. The tooth loads generally are less on the hypoid gear; for example, in this pair the resultant of all components is 1090 lb., as compared with 1193 lb. normal tooth-load on the spiral bevel. Axial thrust of the spiral-bevel pinion is 620 lb. on forward drive, and this is increased to 649 lb. for the hypoid pinion. On reverse drive the thrust is reduced from 495 lb. on the spiral bevel to 489 lb. on the hypoid pinion. Radial pressure on forward drive is 170 lb. on the spiral bevel and 182 lb. on the hypoid, and in reverse drive is 410 and 498 lb. respectively.

Replying to inquiries by others, Mr. Stewart and Mr. Wildhaber said that the difference between the hypoid and helical bevel gears in sensitiveness to radial and lateral yield is not



Arthur L. Stewart Ernest Wildhaber

ASK THEM ABOUT HYPOID GEARS. THEY KNOW

great, the design has to be worked out carefully to take advantage of all possible space for the inner bearing, the maximum amount of offset of the pinion which can be used is slightly more than half of the outside diameter of the gear ring, the hypoid gear has an advantage for truck use in that the pinion has a much larger diameter than a bevel pinion, and larger gear-ratios can be obtained. No tests have been run to determine the power losses but such tests are under consideration. The friction loss is very small. The reduction is the same as with spiral-bevel gears and the ratio of torque transmitted to the pinion shaft is the same.

Experience so far does not indicate that any difficulty will be experienced from change of tooth shape due to heat-treatment. The difference in tooth-contact intimacy on the two sides of the teeth is so slight that it can hardly be detected, and, with the heavier axles used in trucks, the tendency of the teeth with left-hand curvature in the overhung drive to draw toward the center of the ring gear and wedge can be nullified by rigidity of axle construction. The practical gear-ratios so far used are as low as 4 to 1 and up to 6½ to 1; some of 7 and 8 to 1 are under way, and others of 11 to 1 have been laid out. The helix angle can be as high as 60 or 65 deg., which corresponds to a ratio of 15. The average amount of endwise sliding is about 25 per cent, or just about the same for the same peripheral movement as in the worm drive with a 45-deg. angle. The more the offset is increased the more the sliding torque is increased.

DISCUSSION ON WORM DRIVE

Several exceptions were taken by John Younger, John McGeorge and C. L. Sheppy to the inference they gathered that Mr. Buckendale dated development of the worm drive from 1917. They told of the successful use of this type of drive in machinery as early as 1888, in Franklin and Pierce-

C. L. Sheppy John McGeorge

THEY DISCUSSED THE GEAR PAPERS

TWO PROMINENT DISCUSSERS AT THE SUMMER MEETING
W. G. Wall, Who Participated in the Discussion at the Riding-Qualities Session, Listening to a Dissertation on Gears by John Younger

Arrow trucks in 1909 and earlier, and in English passenger cars in 1905 or 1906, when Mr. Younger said he drove a worm-drive passenger car at 75 m.p.h. About 12 per cent of present English makes of car are worm driven, he said.

Mr. Buckendale disclaimed any intention of conveying the impression that worm-driven development began in 1917; his own investigation of the subject showed that it started before he was born; his reference was to work that had been done in automotive gearing in volume production.

The straight type of worm requires practically no adjustment for wear, he said, as the material is given all the necessary properties to resist wear and the gears maintain their correct initial tooth-contact. His company is carrying on experiments with babbitted metal gears for double-deck motorcoaches operating at an average speed of 18 m.p.h., but the metal does not seem to have the bearing and resisting qualities desired, which is the biggest problem, as it is not difficult to get the necessary strength.

O. M. Burkhardt wanted to know why the bevel-gear makers adhere to steel gears and the worm-drive makers to bronze rings having a tensile-strength not much in excess of 40,000 lb. per sq. in. The gear in the hypoid type, which approaches the tangential form of the worm drive, is also made of steel. Gears, he said, should be made with a sufficiently low factor of safety so that they will not burden the rear axle unduly and it is unnecessary to have the gear outlast the car. Bronze is, of course, a better material to resist sliding motion, which predominates in the worm type.

Replying, Mr. Buckendale said that a large number of experiments have been made with different materials and he had used a bevel ring of duralumin that ran quietly for 15,000 miles. Mr. Jeacock, of the Buffalo Bronze Co., told of the development by his company of a process for chilling tin-bronze castings all the way through, whereby the tensile-strength is increased to 48,000 or 50,000 lb. and the Brinell hardness to 100.

If the same relative speed factors, pressures and so forth that are being used on heavy high-speed motorcoaches were used in the new worm gear it could be made very much smaller than at present, but as the passenger-car worm drive is a new field in which experience is limited, the gear surfaces, areas and pressures are purposely being held down until it is learned where the limits are.

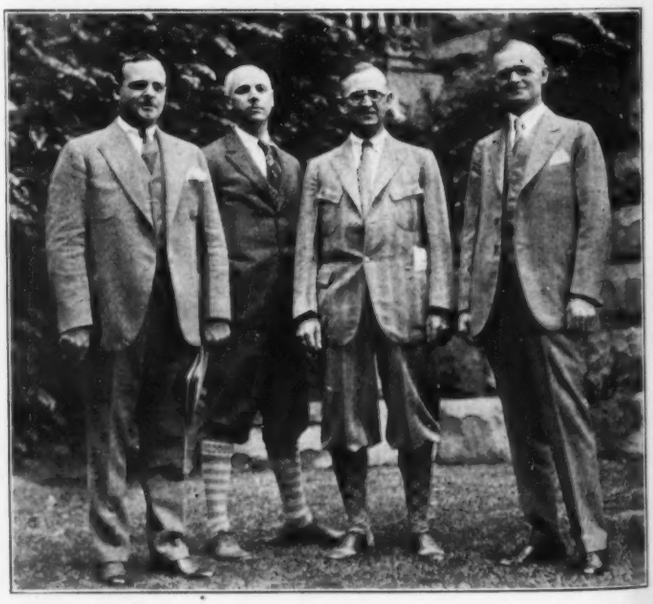
Mr. Sheppy said the major considerations in worm drive for trucks and motorcoaches are ample factors of safety, with settings large enough so that pressures due to engine torque will not become abnormal; adequate lubrication; freedom from deflection of the worm under stress; and ample bearings. To which Mr. Buckendale responded that too much emphasis could not be placed on the importance of preventing deflection or displacement of the gears when under load, which applies to all types of gear.

IMPACT TESTS AND BALLOON-TIRE RIMS

Cooperative Motor-Truck Test-Results and Drop-Center-Rim Design Described

Two important and valuable papers were presented at the Tire and Rim Session that was held on Friday afternoon, June 4. Balloon Tires for Use with Drop-Center Rims was the title of B. J. Lemon's paper, and it will be found printed in full on p. 623 of this issue of THE JOURNAL. The other paper, General Results of the Cooperative Motor-Truck Impact-Tests, by J. A. Buchanan and J. W. Reid, is also printed in full on p. 581. C. M. Manly presided as chairman.

Following the presentation of the papers, several prepared discussions were read and other members participated orally. J. W. White said in part that the real advantage in the adoption of a successful drop-center design accrues mainly to the car builder. He believes that, when properly developed, the drop-center equipment is inherently lighter in weight than the present flat-base-rim type of construction and, because it is a one-piece rim, it offers much in the line of simplicity, ruggedness and ease of assembly over the present type, with a corresponding reduction in cost. In view of its possible adoption in this Country, Mr. White analyzed some of the defects that have become evident in drop-center tires and rims as thus far used experimentally in the United States. He stated that the first and most important difficulty is tube pinching. The drop-center rim requires a tube of larger cross-section and smaller diameter than is used in the flat-base construction. This is because of difficulty experienced under inflation to get the standard tube to fit the well without undue stretch; so, a tube for drop-center requirements is from 3 to 4 in. shorter than the standard tube so that normally it will inflate the well portion first and the tire last, which means that the inflated tube rests in the well. After comparing several English and American rims by lantern slides and comments thereon, Mr. White concluded by saying that it appears the problems of tube pinching, tire seating and having the tire come off the rim when punctured are inter-related. It seems that the English have solved these difficulties to a greater or lesser degree by the use of shallower wells, better well-angles, narrower tire beads, and a tube construction that is nearer to standard practice. He said also that, from the standpoint of adoption, it seems that the urge for drop-center-rim development must come from



FOUR WHO ATTENDED THE TIRE AND RIM SESSION
From Left to Right They Are N. A. Baker and J. E. Hale, of Firestone Tire & Rim Co., C. C. Carlton, of Motor Wheel Corporation, and J. G. Swain, of Firestone Steel Products

the car builder as a result of benefits to be gained through car performance; but he believes it evident that more experimenting must be done to make the rim suitable.

Drop-Center Rim Manufacturing-Methods

As presented by H. W. Kranz, the method of manufacturing the airplane drop-center rim, also identified as the American-type drop-center rim, and that for making inverted-beam drop-center rims, according to the practice of the Cleveland Welding & Mfg. Co., were outlined. For the airplane drop-center rims, flat hot-rolled strip-steel is used as raw material. This is formed or hooped into circular shape; then, it is welded and the weld-burr is removed. After this, the hoop is put into special rim-rolling machines equipped with guides to assure proper handling of the material and is caused to be cold-formed or rolled through a series of operations that were depicted in lantern-slide views while Mr. Kranz explained the various operations of rolling and sizing. For the inverted-bead drop-center rim, similar raw material is used, but the various operations of cold-rolling and sizing are somewhat different. Views of these operations were shown and explained.

In connection with Mr. White's remarks, Dr. Lemon read

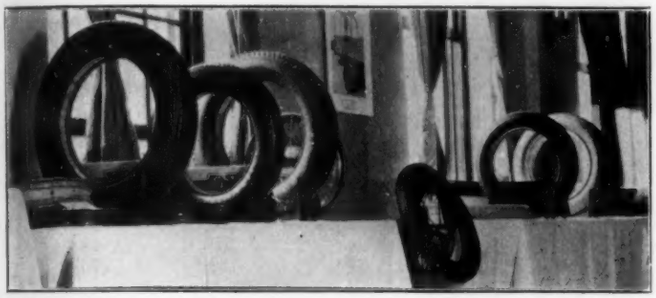


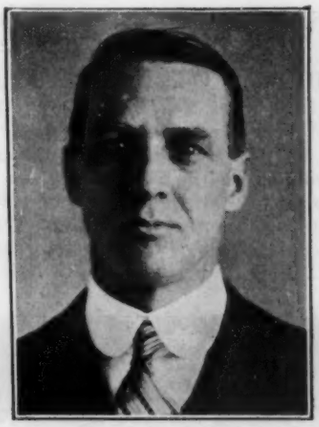
Exhibit Accompanying the Lemon Paper

recent information that he had received which emphasized the importance of a new shallow welded-rim for use with the 29 x 4.40-in. tire. He said that this new rim is not yet included in standard production, but it has behaved so well under test that British manufacturers would be willing to adopt it as standard if an agreement can be reached for international standardization along the lines of this type of section. It was said that the American manufacturer favors somewhat wider rims, and that it should be noted that the width of this new section is slightly greater than that of the standard. Because of its general proportions, it is claimed that it is practically impossible for anyone fitting the tire to inflate it and leave the tire in any other than its correct seating all the way around. Also, it was stated that the new rim provides a considerable economy in tube cost because a normal round-section tube can be used safely. Dr. Lemon said that the attachment and detachment are fairly easy and can be performed with the aid of one or two small levers.

Longitudinal-Shock Components

In his written discussion of the Buchanan and Reid paper, Benjamin Liebowitz said in part that the impact results presented should be interpreted with the test conditions and the instrumentation characteristics kept clearly in mind. In nearly all cases, the "shock" or primary impact in striking a bump is found to be less than the "drop" or secondary impact when the wheel meets the road after completing its trajectory. In considering this result it should be remembered that only the *vertical* road-reactions were measured and Mr. Liebowitz said that to obtain a complete picture of the relative intensities of "shock" and "drop" it will be necessary to determine the *longitudinal* values also.

Mr. Liebowitz went on to say that the foregoing remark applies to all the results presented to show the influences of unsprung-weight and speed. For instance, while under certain conditions, with flexible tires, a large unsprung-weight contributes to riding-comfort, the evidence is not sufficient for the statement that



C. M. Manly B. J. Lemon

The Chairman Who Presided at the Tire and Rim Session and the Author of the Paper on Balloon Tires

> From a cushioning point of view, the combination of a low-pressure balloon-tire, a relatively heavy unsprung-weight and a comparatively flexible truck-spring might substantially eliminate all but the severest road-roughness.

Measurement of longitudinal-shock components might tell a different story, according to Mr. Liebowitz, at least under some conditions, and he enlarged upon his views in this regard, including also a mathematical analysis.

General Discussion and Motion Pictures

Answering Mr. Liebowitz in part, Mr. Buchanan altered the foregoing quotation to read "*might* substantially eliminate all but the impact reactions," stating further that the authors are not saying that it *does* eliminate them. They offer it merely as a helpful suggestion. Chairman Manly read a series of questions from A. L. Schoff, of the Overman Cushion Tire Co., relating to specific points and illustrations concerning the impact tests, and these, with the replies, will be included when the complete discussion is printed. In connection with deduction (7), as printed in the paper, "appreciable variation of cross-sectional rubber, or breaks in its continuity, causes heavy repeated impacts on the road," Mr. Manly remarked that this is tied-up with the matter of distance between the breaks and with the cross-section. He said that there may be breaks or substantial changes in a cross-section of the rubber that do not produce impact due to the fact that their positions are so close together that there is no appreciable variation in the radial compressibility of the tire in any particular circumferential position and, if that is true, there is then nothing to produce an impact.

Motion pictures of all details of the actual motor-truck impact-tests were exhibited at the close of the discussion.

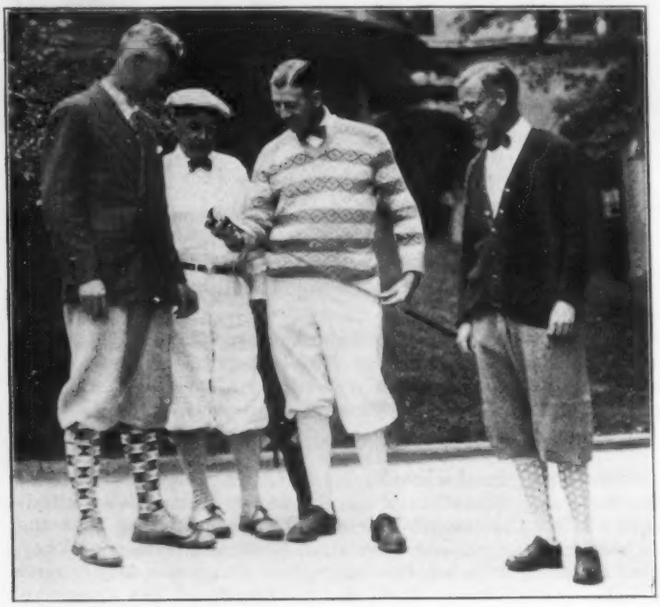
J. W. Reid James A. Buchanan

The Paper on Impact-Tests Was the Joint Work of This Pair

SANFORD BROWN 1926 GOLF CHAMPION

He Wins One Up Over John Taylor, the Scores Being 74 and 75 Respectively

Of the more than 200 players who entered the qualifying rounds on the Hill Course on Tuesday and Wednesday, the players with the eight lowest qualifying scores were included in the Championship Flight, the winner of which was decided by match play. In the first round J. H. McDuffee defeated John L. Dole 8 up, John Taylor defeated J. W. Bryant, Jr., by default, H. LeBlond defeated F. A. Thompson 4 up, and Sanford Brown defeated R. L. Wilkinson 2 up. In the semi-final round Taylor defeated McDuffee 1 up and Brown defeated LeBlond 2 up. In the final round Sanford Brown became the Society's 1926 golf champion by defeating Taylor 1 up. Par for the course is 72 and the scores of 74 and 75 for Brown and Taylor respectively were considered excellent golf, the play really being in the professional class. The score hole by hole is given in the accompanying table. George H. Ralls, the 1925 champion, was not able to qualify for the Championship Flight.

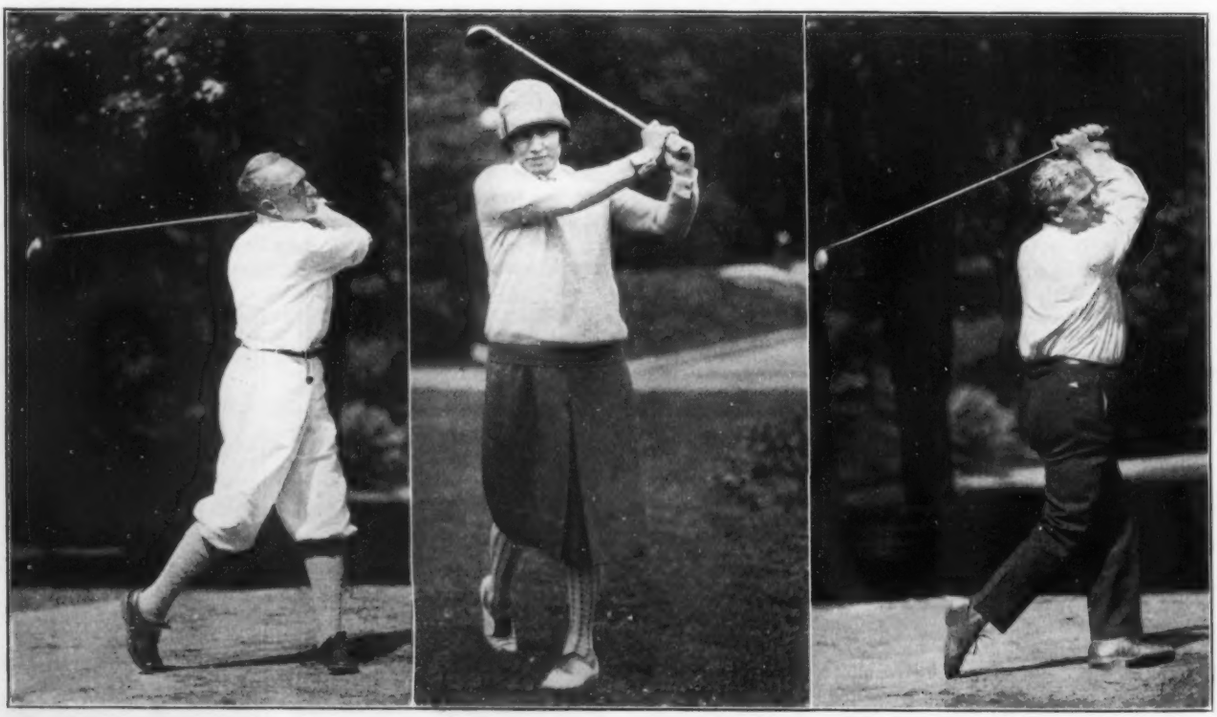


A Quartet of Enthusiastic Golfers
R. J. Dickey, J. M. Watson, C. E. Salisbury, and Jack Gray, Reading from Left to Right in the Order Named

SCORE HOLE BY HOLE OF FINAL ROUND

Hole	Yd.	Par	Brown	Taylor
1	418	4	4	5
2	385	4	4	3
3	390	4	3	4
4	164	3	3	3
5	453	5	4	5
6	205	3	3	4
7	490	5	4	5
8	370	4	5	4
9	348	4	4	4
Out	3,223	36	34	37
10	388	4	5	4
11	330	4	5	4
12	405	4	4	3
13	203	3	3	4
14	595	5	5	6
15	452	5	5	5
16	130	3	4	3
17	370	4	5	5
18	394	4	4	4
In	3,267	36	40	38
Total	6,490	72	74	75

The men with the next lowest 64 qualifying scores were divided into four flights of 16 players each and handicaps for each player were set by Joseph Bijur, chairman of the Golf Committee, the handicaps being based on the players' own club handicaps and their qualifying scores. The winners of these four flights were:



A Trio of Golfers
Joseph Bijur, Chairman of the Golf Committee; Mrs. R. Fries, Winner of the Ladies' Championship, and David Beecroft, Who Swings a Drastic Driver

HE'S A BRAW LADDIE, YE KEN
Sanford Brown, Winner of the Men's Golf Championship from John Taylor by a Score of 74 to 75, Par for the Course Being 72

Class A Flight	Joseph Bijur
Class B Flight	C. E. Salisbury
Class C Flight	F. S. Slocum
Class D Flight	R. S. Drummond

The gross and net scores and the handicaps for the players in these flights were as follows:

CLASS A FLIGHT

Joseph Bijur, 84-11-73; F. C. Thompson, 87-11-76; John W. White, 89-13-76; R. J. Dickey, 90-11-79; E. O. Jones, 93-14-79; J. R. Jones, 92-12-80; L. V. Cram, 96-13-83; Russell S. Begg, 98-14-84; George Ralls, 92-6-86; H. D. Hukill, 97-11-86. W. S. Harley, M. Howard Cox and F. E. Badger qualified for this flight but did not play.

CLASS B FLIGHT

C. E. Salisbury, 84-14-70; G. A. Young, 88-16-72; George W. Tall, Jr., 88-15-73; Ernest Wooler, 99-21-78; J. B. Funk, 94-13-81; A. A. Bull, 99-17-82; E. H. Belden, 103-14-89. C. B. Johnson, W. C. Acklin, T. N. Bourke, Stanley Whitworth, Kirk W. Connor, James T. Kennedy, and C. B. Wisenburgh qualified for this flight but did not play.

CLASS C FLIGHT

F. S. Slocum, 94-19-75; Mason Rumney, 97-20-77; L. M. Clegg, 99-22-77; J. F. Cast, 101-22-79; J. G. Monjar, 99-19-80; E. H. Ehrman, 100-20-80; R. E. Carpenter, 102-21-81; J. H. Nelson, 103-22-81; L. Dunning, 98-15-83; C. C. Carlton, 104-20-84; C. F. Clarkson, 106-22-84; Louis Chevrolet, 106-20-86. C. W. Eggenweiler, R. H. Demott, A. A. Warner, and Casey Jones qualified for this flight but did not play.

CLASS D FLIGHT

R. S. Drummond, 91-22-69; J. B. Eccleston, 96-22-74; J. F. Winchester, 99-25-74; J. T. Libbey; 101-26-75; J. A. Gelzer, 100-23-77; J. M. Watson; 104-26-78; J. B. Wright, 110-26-84; H. Brewer, 112-25-87. H. L. Watson, G. T. Briggs, W. C. Robb, H. R. Portugal, J. J. Balsom, T. H. White, and D. S. Devor qualified for this flight but did not play.

The lowest qualifying score of 77 was made by J. H. McDuffee. McDuffee was defeated in the Championship Flight, however, by Taylor 1 up, match play being used in the Championship Flight and medal play in the Class A, B, C, and D Flights.

Credit is due Mr. Bijur, who as Chairman of the Golf Committee was responsible for the running of the tournament and the setting of the handicaps.

The ladies golf tournament was played on the Valley Course, the 16 players that qualified being assigned handicaps. The scores were as follows:

Mrs. R. E. Fries, 98-18-80; Mrs. J. R. Jones, 96-14-82; Mrs. F. C. Thompson, 100-14-86; Mrs. G. H. Ralls, 99-11-88; Mrs. J. B. Funk, 99-10-89; Mrs. Ernest Wooler, 105-16-89; Mrs. Jack Gray, 102-11-91; Mrs. Stanley Whitworth, 111-14-97; Mrs. Norman Bell, 115-15-100; Mrs. O. A. Parker, 120-20-100; Mrs. W. C. Acklin, 113-12-101; Miss C. S. Houston, 113-10-103; Mrs. P. J. Durham, 141-28-113.

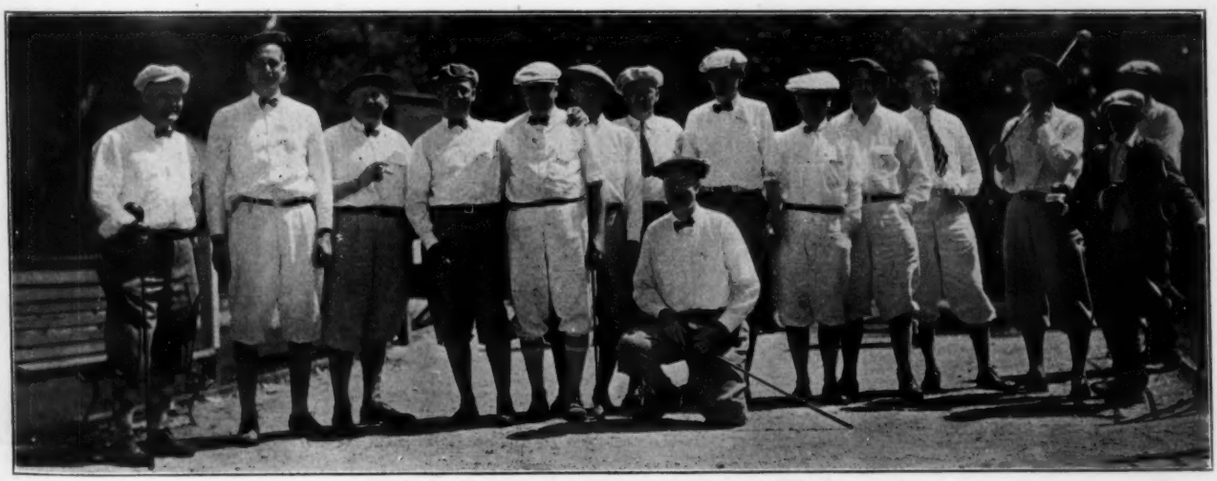
In the men's driving contest, played on the 18th fairway of the Valley Course and slightly uphill, Sandy Brown won first place with a drive of 235 yd., second place going to H. D. Hukill with a drive of 232 yd. The putting contest for ladies was won by Mrs. David Beecroft, second place going to Mrs. R. H. DeMott.

CLAY PIGEONS FALL BEFORE MARKSMEN

R. S. Ellis Wins Trap-Shooting Trophy; G. A. Gastineau First in Quail Event

Dry Hollow, French Lick Springs, which has been the scene of many noteworthy shooting contests, added another notch to its stick in the competition during the Summer Meeting. In addition to the fame of the place, the marksmen had for inspiration the shrill whistling of the quail that soared up from the neighboring fields and the comments of a large gallery of French Lickians who tempered their admiration with censure when the occasion called for it.

R. S. Ellis captured the trophy for trap shooting on the last day of the contest, Friday, after the score of entries had been whittled away to 4 in 2 days of preliminary shooting. The distance was 16 yd., and each contestant was allowed 50 targets. Mr. Ellis's winning score was 47. Louis Chevrolet and W. S. Harley tied for second place with 44. In the shoot-off, with 25 targets, Mr. Chevrolet broke the deadlock with a



SOME OF THE FOLLOWERS OF THE ANCIENT AND HONORABLE GAME
Golf Was a Favorite Sport at French Lick Springs, Two 18-Hole Courses Being Available

BREAKING CLAY PIGEONS WAS ALSO A POPULAR PASTIME
R. S. Ellis Captured the Trap-Shooting Trophy on the Last Day of the Meeting by Breaking 47 Out of a Possible 50 Birds

score of 24, while Mr. Harley failed to puncture two of the clay pigeons. E. S. Twining, the fourth man to qualify, with a score of 46, was obliged to leave before the finals were run off.

G. A. Gastineau won the quail event. In the first trial he brought down 13 of the 15 sailing targets allowed, which, with his handicap of 2, gave him a net score of 15. F. C. Booth, with a handicap of 5 also made a perfect net score. In the shoot-off Mr. Gastineau repeated his first performance, while Mr. Booth's score fell to 14.

On Wednesday and Thursday trophies were given for the highest net scores attained in each of Classes A, B and C of the Lewis Class Division. Winners Wednesday and Thursday respectively, together with the scores, were as follows:

Class A—W. S. Harley, 48; E. S. Twining, 46.
Class B—O. C. Lang, 42; L. L. Williams, 39.
Class C—C. L. Sheppy, 27; L. A. Chaminade, 32.

Mr. Harley's score was the highest made in the 3 days' shooting. In the practice shoots, on Tuesday, O. C. Land in one instance brought down 25 out of 25 targets.

Lon R. Smith was in charge of this event.

DETROIT WINS BASEBALL CUP BY DEFAULT

After practising all Thursday afternoon, the Detroit team under the captaincy of Shorty McMillan waited from 4:00 p.m., the time scheduled for the game between Detroit and Cleveland, until dark, but Harry Figgie's team failed to appear, an occurrence ordinarily condoned at French Lick Springs. However, owing to the importance of the game, both Detroit and Cleveland having won two legs on the Inter-Section Baseball Cup, the Sports Committee ruled that Detroit won by default. The cup consequently becomes the permanent property of the Detroit Section.

DETROIT STOPS METROPOLITAN SECTION

After winning the Inter-Section Trophy four times in succession, the Metropolitan Section was finally overwhelmed by the Detroit Section, the latter thus winning the second leg for the present Inter-Section Trophy, which, when won three times by a Section becomes the property of that Section. The first cup was won in 1924 by the Metropolitan Section after three consecutive victories. The medal for the All-Round Champion was won by Sanford Brown.

CHICAGO CHUMS WIN HORSESHOE HONORS

Jorgenson and Schulze Reach Single Finals and Form Winning Doubles Team

After a closely fought match in which more than a score of competitors took part, C. H. Jorgenson of the Chicago Section defeated W. H. Schulze of the same Section in the single finals of the horseshoe pitching contest. The score for the concluding match was 21-10, 18-21, 21-10. The contest was extended over all Wednesday afternoon to enable competitors to work out their heats and ended only when Chicagoan met Chicagoan with the results stated. John J. MacFeiggan placed third.

In the doubles, Mr. Schulze and Mr. Jorgenson joined forces, and out-pitched J. T. Libbey and A. H. d'Arcambal, 21-15, 21-17. Although close friends, the two winners had never seen each other play and did not know of their common prowess, so that their partnership was purely fortuitous. A. D. T. Libby, a winner in horseshoe events at previous Summer Meetings was not a competitor, apparently being satisfied with letting the mantle fall on one of his own, or nearly his own, name. He also very generously furnished the horseshoes and other paraphernalia with which the contest

PITCHING HORSESHOES ALWAYS ATTRACTS ATTENTION
Chicago Carried Off the Honors in This Contest, the Winner of the Single Championship and the Runner-Up Combining Forces to Win the Doubles Match

BASEBALL ALSO ATTRACTED A NUMBER OF PLAYERS
The Game for the Society Championship Was Not Played, Since the Cleveland Section Team Did Not Appear at the Scheduled Time and the Detroit Section Was Declared the Winner of the Cup by Default

was played. The third team in the doubles was C. T. Klug and W. J. Buettner, which was defeated by the Libbey-d'Arcambal combination.

Others who pitched the horseshoes were O. C. Berry, A. L. Hopkins, J. F. Winchester, G. A. Schreiber, R. W. Keeley, J. F. Cast, R. J. Nightingale, C. F. Gilchrist, E. O. Jones, E. S. Reeser, C. F. Oestermeyer, Daniel Roesch and S. F. Lentz.

Mr. Buettner was chairman in charge of this event. Much of the smoothness of the arrangements, he said, was due to the efforts of W. L. McGrath, his able assistant.

NEARLY 200 LADIES ATTEND

Card Games, Sports and Other Activities Pass the Time at French Lick

A variety of entertainment was provided for the feminine contingent at the Summer Meeting. Upon arrival each lady found in her mail box at the hotel a card of greeting, welcoming her to the Summer Meeting and requesting her presence at the reception held at the Club on Tuesday afternoon. Those who attended the reception spent a pleasant social hour over tea and other refreshments, as they formed or renewed acquaintanceship with the other ladies present.

THEIR WIVES AND LADY FRIENDS
F. E. Watts (at the Left) and E. V. Rippingille, the Other Male Member of the Contingent, Seem To Be Having a Good Time

Southward from French Lick to the village of Shoals was the route followed on Wesdnesday morning when 50 ladies enjoyed a 40-mile sight-seeing tour, leaving at 10:30 and returning in time for luncheon.

Archery, which was a popular innovation of the 1925 Summer Meeting, was enjoyed again this year, it being difficult to state who derived the most pleasure from this activity—the participants, the spectators or Azel Ames who directed it. Prizes were awarded to the following contestants: Mrs. W. L. McGrath, Mrs. E. R. Jackson and Mrs. W. H. Fenley.

EMULATORS OF DIANA
Archery, Which Was an Innovation at White Sulphur Springs in 1925, Again Attracted Many of the Fair Sex

Bridge was a feature of Thursday morning and afternoon and Friday morning. The winners on Thursday morning

HEEDING THE SCRIPTURAL INJUNCTION
Louis Chevrolet Is Not Letting His Right Hand, Which Is Resting on Mrs. F. S. Duesenberg's Shoulder, Know What His Left Is Doing. The Other Lady? Why, She Happens To Be His Wife

ARE THEY "COMING OR GOING"?
Sightseeing Trips by Motorcoach Was One Form of Entertainment Provided for the Ladies

were Mrs. F. M. Holden, Mrs. C. F. Estermeyer and Mrs. F. M. Germane; on Thursday afternoon, Mrs. Stanley Whitworth, Mrs. C. T. Klug and Mrs. Charles Hollerith; and on Friday morning, Mrs. F. S. Duesenberg, Mrs. Arthur Nutt and Mrs. J. B. Funk.

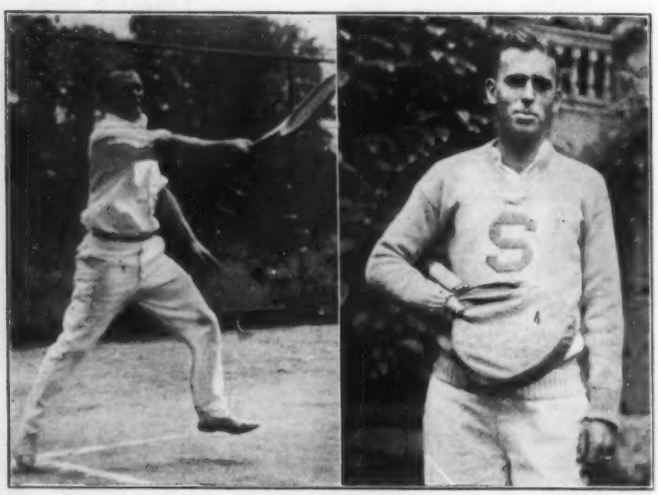
In addition to these activities, the ladies at the Summer Meeting played golf and tennis and participated in the field sports. An account of these events is published elsewhere. Motion pictures and dancing were enjoyed each evening.

The presence of the ladies contributed materially to the success of the Summer Meeting, and it is hoped that an even larger number of them will attend in 1927.

SHIDLE AGAIN TENNIS CHAMPION

Although this year all players in the tennis singles received a handicap of plus 15 with the exception of Norman G. Shidle, the 1925 tennis champion, Shidle again won the championship, the score of the final match being 7-5, 6-1 and 7-5, with B. J. Lemon the runner-up. The tennis courts were in very bad condition and were also marked incorrectly, making championship tennis almost impossible.

In the doubles, Johnson and Burke defeated Sanford and Cole three sets out of four and won the doubles championship. In the ladies' singles, Mrs. H. D. Hukill won the championship by defeating Mrs. Alvan Macauley, Jr.



OPPONENTS IN THE FINAL ROUND OF THE MEN'S TENNIS TOURNAMENT
B. J. Lemon (at the Left) Was Defeated by Norman G. Shidle, Last Year's Champion (at the Right), the Score Being 7-5, 6-1, 7-5

THE LADIES' TENNIS CHAMPION AND THE RUNNER-UP
Mrs. Alvan Macauley, Jr., (at the Left) Was Defeated in the Final Round by Mrs. H. D. Hukill, Who Is Seen in Action at the Right

J. H. HUNT NOMINATED FOR PRESIDENT

Nominating Committee for 1927 Officers Takes Prompt Action at Summer Meeting

The personnel of the annual Nominating Committee of the Society, provided for by the Constitution, was completed at the Business Session of the Summer Meeting by the election of the following as members at large of the committee: E. H. Ehrman, of Chicago, Thomas Midgley, Jr., of Dayton, and R. E. Plimpton, of New York City.

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J. H. HUNT

The annual Nominating Committee consists of members elected by the Sections, one each, and three members at large as indicated above. Those designated this year by the Sections as representatives and alternates were as follows:

Buffalo Section
J. W. White (Arthur Nutt, alternate)
Chicago Section
O. B. Zimmerman (D. P. Barnard, 4th, alternate)
Cleveland Section
H. D. Church (Balfour Read, alternate)
Dayton Section
F. W. Heckert (F. G. Shoemaker, alternate)
Detroit Section
W. R. Strickland (L. C. Hill, alternate)
Indiana Section
F. E. Moskovics (F. F. Chandler, alternate)
Metropolitan Section
Neil MacCoull (A. F. Masury, alternate)
Milwaukee Section
F. M. Young (J. J. Balsom, alternate)
New England Section
E. P. Warner (Rollin Abell, alternate)
Northern California Section
E. C. Wood
Pennsylvania Section
G. W. Gilmer, Jr. (A. K. Brumbaugh, alternate)
Southern California Section
W. H. Fairbanks
Washington Section
A. W. S. Herrington (H. C. Dickinson, alternate)

The committee at its session held on June 2 nominated the

following Members to serve as officers and members of the Council during the 1927 administrative year:

President—J. H. Hunt
First Vice-President—W. G. Wall
Second Vice-President, representing Motor Car Engineering—F. M. Zeder
Second Vice-President, representing Tractor Engineering—J. F. Max Patitz
Second Vice-President, representing Aeronautic Engineering—E. T. Jones
Second Vice-President, representing Marine Engineering—P. G. Zimmermann
Second Vice-President, representing Stationary Internal Combustion Engineering— C. B. Jahnke
Treasurer—C. B. Whittelsey
Councilors (to serve during 1927 and 1928)—S. W. Sparrow, C. B. Veal, Ernest Wooler

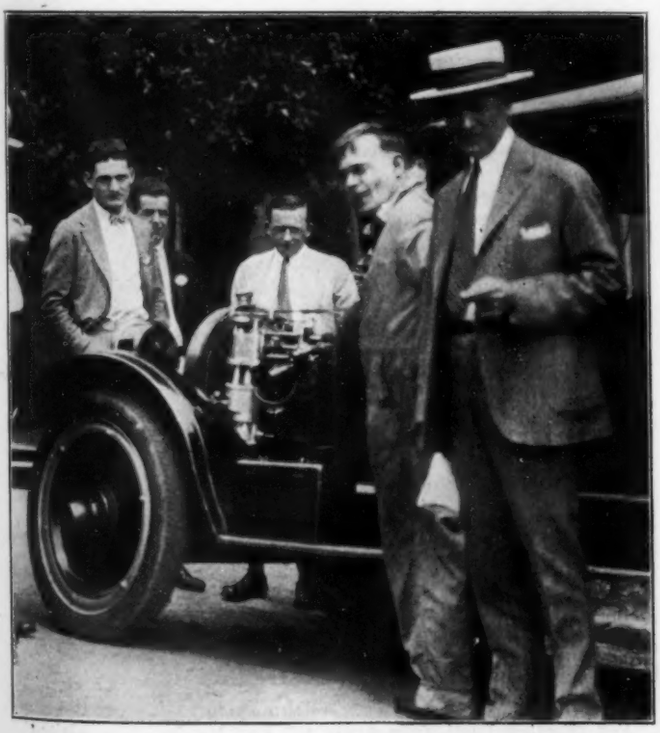
Thirty days before the 1927 Annual Meeting, letter ballots bearing the names of the nominees of the annual Nominating Committee will be mailed to the members entitled to vote. Twenty or more members entitled to vote may constitute themselves a special nominating committee, with the same power as that of the annual Nominating Committee. The By-Laws provide that a special nominating committee if organized shall on or before Nov. 15 transmit to the Secretary the names of the candidates nominated by it for the elective offices next falling vacant under the Constitution, together with the written consent of each.

APPEAL TO THE EYE

Lively Interest Shown in Exhibits and Demonstrations Supplementing Papers

At nearly all the technical sessions of the Summer Meeting those who presented the papers and others succeeded in showing by instruments, apparatus and other exhibits, the how and the why. Slides and charts were utilized extensively.

W. C. Keys demonstrated how cushion springs affect riding-qualities. R. W. Brown showed types of accelerometer for measuring riding-qualities and exhibited apparatus for calibration.



PROF. H. M. JACKLIN DEMONSTRATES HIS ENGINE INDICATOR

P. E. KELECOM DEMONSTRATING THE ACTION OF THE DEWANDRE VACUUM SERVO BRAKE, A BELGIAN DEVICE

K. D. Chambers and his colleague, Loyd Jones, presented a very spectacular demonstration of complementary-color headlighting. Dr. H. C. Dickinson, R. N. Falge and others brought with them for demonstration cars equipped with several different types of headlight; numerous members participated in the tests to demonstrate important headlighting features.

Fred S. Duesenberg illustrated his talk at the Race Session with parts taken from racing cars.

T. S. Sligh, Jr., demonstrated apparatus for determining fuel volatility.

A. L. Stewart, Ernest Wildhaber and L. R. Buckendale used sample parts to make their addresses at the Gear Session more interesting.

J. A. Buchanan and J. W. Reid showed the Bureau of Public Roads coil spring accelerometer. Interesting impact-test motion pictures prepared by the Bureau of Public Roads were also shown. At the same session B. J. Lemon exhibited several types of drop-center rim and a tire.

H. M. Jacklin, of the Ohio State University, was very active in demonstrating his indicator for high-speed multi-cylinder engines.

The Dewandre Vacuum Servo Brake was demonstrated by P. E. Kelecom, of the Dewandre Vacuum Servo Brake Co., of Belgium.

EVERYBODY COOPERATED CHEERFULLY

Meetings Committee and Others Warmly Congratulated for Successful Meeting

Without the active support and cooperation of many persons it would be impossible to arrange and carry through a successful Summer Meeting. The spirit of helpfulness was admirably shown in connection with every feature of this year's meeting, and it is to be hoped that those who assisted may have been amply compensated for their efforts by the appreciation that was expressed from all quarters.

The Meetings Committee, L. Clayton Hill, chairman, was, of course, responsible for the arrangement of the program and the general conduct of the meeting.

The following persons are worthy of receiving credit because of their activities in connection with the technical sessions as noted elsewhere in this issue:

CHAIRMEN OF SESSIONS

L. Clayton Hill
E. C. Crittenden
C. M. Manly
C. D. McCall
F. E. Moskovics
H. C. Mougey
J. W. White
J. F. Winchester

AUTHORS AND SPEAKERS

R. W. Brown
J. M. Buchanan
L. R. Buckendale
O. M. Burkhardt
K. D. Chambers
H. K. Cummings
A. W. Devine
F. S. Duesenberg
R. N. Falge
W. A. Gruse
J. H. Hunt
Loyd Jones
C. F. Kettering
W. C. Keys
B. J. Lemon
C. J. Livingstone
S. P. Marley
Harry Miller
J. W. Reid
T. S. Sligh, Jr.
A. L. Stewart
E. Wildhaber

SPORTS COMMITTEE

A. W. Herrington, *Chairman*

E. W. Austin
Joseph Bijur
George T. Briggs
B. Brodt
A. K. Brumbaugh
T. V. Buckwalter
W. J. Buettner
C. F. Gilchrist
Ferdinand Jehle
B. J. Lemon
A. D. T. Libby
G. A. Round
C. L. Sheppy
Lon R. Smith
S. W. Sparrow
C. B. Veal
E. P. Warner
F. G. Whittington
J. F. Winchester

LADIES' ENTERTAINMENT COMMITTEE

Mrs. F. S. Duesenberg, *Chairman*

Mrs. B. B. Bachman
Mrs. C. F. Clarkson
Mrs. E. H. Ehrman
Mrs. A. W. Herrington
Mrs. H. L. Horning
Mrs. W. S. James
Mrs. C. F. Kettering
Mrs. C. T. Klug
Mrs. T. J. Litle, Jr.
Mrs. J. W. White

Other events were handled by the following: Mrs. L. Clayton Hill, T. Milton, Azel Ames, Mrs. B. Brede, Mrs. Norman Bell, Mrs. Jack Gray, Mrs. Lon R. Smith, Mrs. O. C Berry, E. V. Rippingille, John Younger, and A. J. MacDowell.

Air-Photo Personnel

Mason P. Rumney, chief of staff, and A. W. Herrington, chief assembly officer, could not have made the airplane photographic exhibition a success without the assistance of the following:

C. O. Guernsey, Norman Bell, George Briggs, R. F. Buckley, T. V. Buckwalter, John Cautley, John Younger, F. A. Cornell, A. G. Herreshoff, Walter Keys, B. J. Lemon, H. O. K. Meister, R. S. Begg, R. E. Plimpton, G. A. Round, J. W. White, F. G. Whittington, O. W. Young, E. P. Warner, H. K. Cummings, T. S. Sligh, Jr., C. B. Veal, F. M. Young, E. W. Austin, O. C. Berry, H. D. Hukill, Sanford Brown, H. E. Figgie, Miss J. A. McCormick, Mrs. Norman Bell, Mrs. Ernest Dickey, Mrs. Jack Gray, Mrs. A. W. Herrington, Mrs. L. Clayton Hill, Mrs. H. D. Hukill, Mrs. J. H. Hunt, Mrs. C. T. Klug, Mrs. E. R. Jackson, Mrs. Lon R. Smith, R. Insley, T. Hanrahan, William Bernstorff, Dr. S. M. Burka, Lieut. G. W. Goddard and H. W. Perry.

The Hyatt Roller Bearing Co. deserves great praise for providing the *Daily SAE*. Through the efforts of members of the Campbell-Ewald organization, the sheet this year was one of the best ever published at a Summer Meeting.

Appreciation is due the Indiana Section for their splendid hospitality and for marking the best route to the site of the meeting.

The Prest-O-Lite Co. at Indianapolis very courteously provided free parking space for automobiles and railroad coaches; also a complimentary luncheon to visiting members.

Members of the Chicago, Cleveland, Dayton, Detroit, Metropolitan, and Indiana Sections who succeeded in staging the wonderful series of stunts are to be congratulated and thanked.

Major J. F. Curry, commanding officer of McCook Field: Lieut. G. W. Goddard and Dr. S. M. Burka of the same Army post were responsible for the success of the airplane-photographic exhibition and deserve great praise and appreciation. Others who participated in the air-photo venture and in the convention-by-airplane stunt were Lieut. V. E. Bertrandias, F. W. Heckert, J. M. Miller, F. G. Shoemaker, T. C. MacMahon, J. Rauen, Stanley Somers, Bennie Thomas, and R. Insley. L. G. Meister was helpful in arranging to have the air-photo exhibition provided.

Thomas Taggart, Jr., and J. E. Brown of the French Lick Springs Hotel did everything in their power to make the members happy. They succeeded admirably.

Miss Chilles and her assistants from the Chicago branch of the Master Reporting Co. did very creditable work in preparing the transcript of the technical sessions.

Everybody helped, and it is hoped that those whose names are not specified above will realize that their efforts also were appreciated.

SOUVENIRS PRESENTED

Remy and Spicer Respectively Distribute Hats and Golf Balls

Soon after the Summer Meeting opened, the members blossomed out with very attractive hats of the tam-o'-shanter variety that were provided through the courtesy of the Remy Electric Co.

Golf enthusiasts were very appreciative of the golf balls that were given by the Spicer Mfg. Corporation.

A GENEROUS PRIZE FUND

Subscribed by Prominent Manufacturers Provides Attractive Awards

Many handsome prizes that were won by those who competed in various events at the Summer Meeting were purchased with funds that were offered by a large number of prominent manufacturers who have shown great interest in the Society's activities and who were desirous of demonstrating their support in a tangible way. Subscriptions, limited to $10 each, from the organizations listed below, totaled a sufficient sum to cover the cost of prizes for both the 1925 and 1926 Summer Meetings.

The members wish to have the subscribers to the Prize Fund realize that their interest is greatly appreciated.

Aetna Ball Bearing Mfg. Co.
Aluminum Co. of America
American Bosch Magneto Co.
American Chain Co.
American Felt Co.
American Motor Body Corporation
Armstrong Cork Co.
Auburn Automobile Co.
Bakelite Corporation
Bassick Mfg. Co.
Bearings Co. of America
Belflex Corporation
Bendix Brake Co.
Bijur Lubricating Corporation
Bock Bearing Co.
Bohn Aluminum & Brass Corporation
Robert Bosch Magneto Co., Inc.
Boston Insulated Wire & Cable Co.
Bound Brook Oilless Bearing Co.
Briggs & Stratton Corporation
J. G. Brill Co.
Geo. W. Brogan, Inc.
Brown Lipe Chapin Divi-

"Oh, Listen to the Band"
For "Further Particulars Apply to" Any Member Who Visited French Lick Springs

sion of General Motors Corporation
Brunner Mfg. Co.
Buda Co.
Edward G. Budd Mfg. Co.
Budd Wheel Co.
Buick Motor Co.
Bunting Brass & Bronze Co.
Byrne, Kingston & Co.
C. G. Spring & Bumper Co.
Cadillac Motor Car Co.
Campbell-Ewald Co.
Carnegie Steel Co.
F. S. Carr Co.
Carter Carburetor Corporation.
Central Steel Co.
Champion Spark Plug Co.
Chevrolet Motor Co.
Chilton-Class Journal Co.
Chilton Co.
Clark Equipment Co.
Cleveland Automobile Co.
Cleveland Graphite Bronze Co.
Cleveland Twist Drill Co.
Commercial Truck Co.
Continental Motors Corporation
Cook Spring Co.
Cotta Transmission Corporation
Dayton Engineering Laboratories Co.
Dayton Steel Foundry Co.
Denton & Anderson
Deppe Motors Corporation
Detroit Lubricator Co.
Detroit Steel Products Co.
Dickinson Cord Tire Co.
Ditzler Color Co.
F. J. Donahue Varnish Co.
Dunlap Tire & Rubber Corporation
E. I. duPont de Nemours & Co.
Dura Co.
P. J. Durham Co.
Eaton Axle & Spring Co.
Eberhard Mfg. Co.
Eclipse Machine Co.
Edison Lamp Works
Edmunds & Jones Corporation
Electric Auto-Lite Co.
Electric Storage Battery Co.
Ethyl Gasoline Corporation
Fansteel Products Co., Inc.
Fedders Mfg. Co.
Federal Rubber Co.
Fellows Gear Shaper Co.
Fink-Dumont-White, Inc.
Firestone Steel Products Co.
Firestone Tire & Rubber Co.
Fisk Tire Co., Inc.
G & O Mfg. Co.
Gabriel Mfg. Co.
Gardner Advertising Co.
Gardner Motor Co., Inc.
Gemmer Mfg. Co.
L. H. Gilmer Co.
Graham Bros.
Guide Motor Lamp Mfg. Co.
Halowax Corporation
Harter Rolled Metals Co.
Robert H. Hassler, Inc.
Herbrand Co.,
Hercules Motors Corporation
Hershey Mfg. Co.
Holley Carburetor Co.
Hoover Steel Ball Co.
Houde Engineering Corporation
E. F. Houghton & Co.
Hudson Motor Car Co.
Hyatt Roller Bearing Co.
Hydraulic Brake Co.
Indiana Lamp Co.
International Nickel Co.
Interstate Iron & Steel Co.
Isotta Motors, Inc.
Jaxon Steel Products Division of General Motors Corporation
Jordon Motor Car Co.
Keasbey & Mattison Co.
Kellogg Switchboard & Supply Co.
Kelly Springfield Tire Co.
Kerite Insulated Wire & Cable Co., Inc.
Kissel Motor Car Co.
Lambert Tire & Rubber Co.
Lamson & Sessions Co.
Lang Body Co.
Larrabee Deyo Motor Truck Co.
LeRoi Co.
Long Mfg. Co.
Lovejoy Mfg. Co.
McBeth Evans Glass Co.
McCord Radiator & Mfg. Co.
Maccar Truck Co.
Madison-Kipp Corporation
Manley Mfg. Co.
Mansfield Sheet & Tin Plate Co.
Marlin-Rockwell Corporation
Marvel Carbureter Co.
Maxwell Motor Corporation
Mechanics Machine Co.
Michigan Smelting & Refining Co.
Michigan Steel Corporation
Molybdenum Corporation of America
Morgan & Wright
Motor & Accessories Mfrs. Association
Motor Wheel Corporation
Multibestos Co.
Murray Body Corporation
Nagel Electric Co.
National Carbon Co., Inc.
National Lamp Works
National Malleable & Steel Castings Co.
New Departure Mfg. Co.
New Process Gear Co., Inc.
Nice Ball Bearing Co.
Norma-Hoffmann Bearings Corporation
Norton Co.
North East Electric Co.
Oakland Motor Car Co.
Ohio Rubber & Textile Co.
Olds Motor Works
Overman Cushion Tire Co., Inc.
Owen Dyneto Corporation
Oxford Varnish Corporation
Packard Motor Car Co.
Penberthy Injector Co.
Perfection Heater & Mfg. Co.
Pierce-Arrow Motor Car Co.
Pratt & Lambert, Inc.
Prest-O-Lite Co., Inc.
Pure Oil Co.
Racine Radiator Co.
Remy Electric Division of General Motors Corporation
Reo Motor Car Co.
Republic Motor Truck Co., Inc.
Rich Tool Co.
Rico Ignition Co.
Ross Gear & Tool Co.
SKF Industries, Inc.
St. Mary's Wheel & Spoke Co.
A. Schrader's Son, Inc.
Seamans & Cobb Co.
Sheet Steel Products Co.
Shore Instrument & Mfg. Co.
Shuler Axle Co.
A. O. Smith Corporation
Spicer Mfg. Corporation
Splitdorf Electrical Co.
Standard Oil Co. of New York
Standard Oil Co. of Indiana
Standard Steel Spring Co.
Steel Products Co.
Steel Sales Corporation
Sterling Mfg. Co.
Stewart Mfg. Corporation
Stewart Warner Speedometer Corporation
Chas. A. Strelinger Co.
Strom Ball Bearing Mfg. Co.
Stutz Motor Car Co.
Thermoid Rubber Co.
Timken Detroit Axle Co.
Timken Roller Bearing Co.
Toledo Steel Products Co.
Transcontinental Oil Co.
George T. Trundle, Jr., Engineering Co.
Tung-Sol Lamp Works
Union Drawn Steel Co.
United Alloy Steel Corporation
United States Graphite Co.
Universal Products Co., Inc.
U. S. Light & Heat Corporation
Vacuum Oil Co.
Joseph VanBlerck Engine Corporation
VanDorn Electric Tool Co.
VanDorn Iron Works Co.
Vulcan Crucible Steel Co
Vulcan Iron Works
Walker Vehicle Co.
Wanner Malleable Castings Co.
John Warren Watson Co.
Chester N. Weaver Co.
Weaver Mfg. Co.
Westinghouse Air Brake Co.
Wheeling Steel Corporation
White & Bagley Co.
Whitney Blake Co.
Whitney Mfg. Co.
William Wiese & Co., Inc.
Willard Storage Battery Co.
Winton Engine Co.
Wire Wheel Corporation of America
Wolverine Tube Co.
Wood Hydraulic Hoist & Body Co.
Wyman-Gordon Co.
Zenith-Detroit Corporation

PEP IN THE *DAILY SAE*

Hyatt Roller Bearing Co., Through Campbell-Ewald Co., Provides Fine News Medium

To those who attended the Summer Meeting a perusal of the spicy columns of the *Daily SAE* at breakfast was as essential to enjoyment and comfort as was the consumption of the choice edibles—and the little sheet was as sure to be there with its news, wise cracks, predictions, and illustrated stories.

That the paper scored a decided hit is stating the case mildly. All features were in excellent taste and well presented. The "phony" advertisements and special illustrations were noteworthy.

H. A. Brown, Jr.

Be it known that the men who produced the *Daily SAE* executed a difficult task very creditably. Few persons realize how much advance work must be done on a paper of this nature and how great the attention to detail must be during the meeting. The gentlemen who turned the trick were: Editor-in-Chief, F. E. Booth; Business Manager, H. M. Carroll; Managing Editor, W. A. Moffett; Technical Editor, M. J. Morgan; and Sports Editor, D. M. Carson.

Section reporters who assisted included G. T. Briggs, W. J. Buettner, C. O. Guernsey, F. W. Heckert, A. W. Herrington, L. Clayton Hill, C. B. Veal, E. P. Warner, J. W. White, L. L. Williams and F. M. Young

The *Daily SAE* was generously provided for the Society by the Hyatt Roller Bearing Co., H. A. Brown, Jr., general sales manager, with the cooperation of the Campbell-Ewald Co.

It is understood that members of the Society who wish to have copies of the *Daily SAE* can procure them by addressing the Hyatt Roller Bearing Co., Harrison, N. J.

AUTOMOTIVE INDUSTRY HARDLY STARTED

Rickenbacker, Carter, Kettering, Brisbane and Baer, Indianapolis Dinner Speakers

Without doubt one of the most successful dinners ever held by the Indiana Section was that welcoming visiting Society members, which was given at the Indianapolis Athletic Club on the night before the 14th Annual International Sweepstakes. Over 650 Society members and guests attended. The speakers were E. V. Rickenbacker, Judge Solon J. Carter, C. F. Kettering, Arthur Brisbane, and Bugs Baer.

F. E. Moskovics

George T. Briggs

THE TOASTMASTER AT THE INDIANA SECTION DINNER AND THE CHAIRMAN OF THE COMMITTEE HAVING THE AFFAIR IN CHARGE

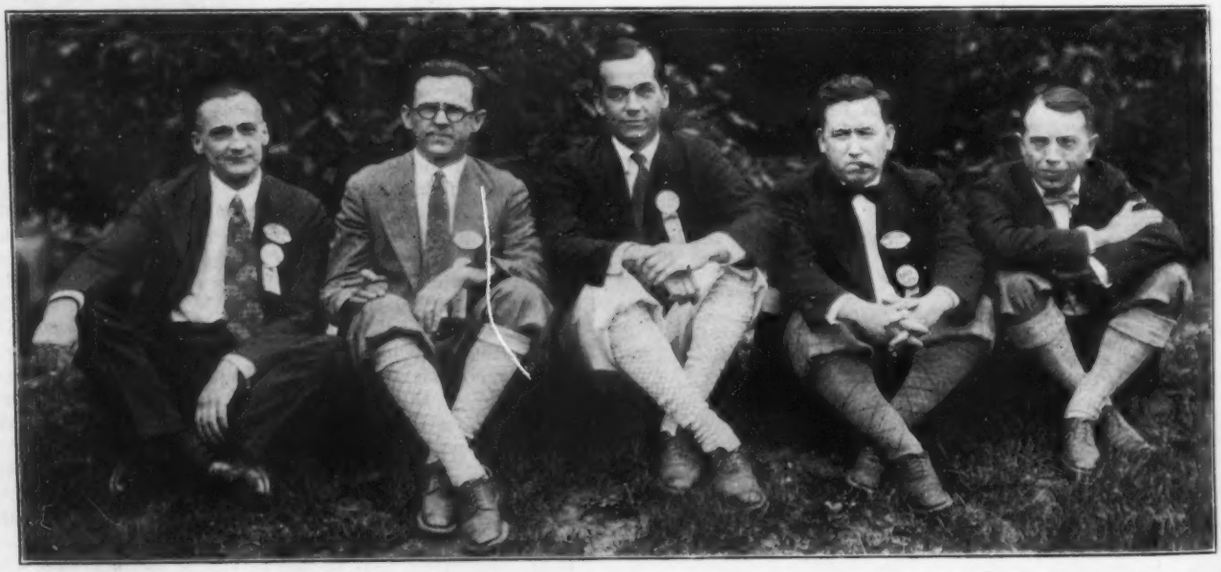
George T. Briggs, chairman of the Indiana Section Committee, welcomed the visiting members and read a letter from Charles M. Schwab, who had been prevented from attending the dinner as originally planned. Mr. Schwab wrote in part:

> As you know, I have been a manufacturer nearly all my life, and I appreciate the value of technical skill, I believe, as well as anyone in the world, so permit me to at least add a few words of praise to you men who have made this great industry what it is today. I am optimist enough to believe that you have only started. The world's fields are before you. When you saturate the rest of the world as you have America, then, in-deed, will your work for humanity be done, and that is a very feasible task.

Mr. Briggs then introduced F. E. Moskovics, who acted as Toastmaster. E. V. Rickenbacker, the first speaker, paid a tribute to the designers of racing cars, as he felt that very few members of the automotive industry had not benefited directly or indirectly from the knowledge gained in racing. He credited 70 per cent of the developments of present production to the automobile racing fraternity. He felt, however, that the industry should be studying the economic possibilities of aircraft for, as the fundamentals of aeronautics are now known, it should be possible for the aircraft industry to develop more in the next 25 years than the automobile industry has developed in the last 25 years. Mr. Rickenbacker pointed out that the only possible future for more rapid transportation was in the air and that air transportation should develop logically into one of the largest industries. He predicted that dirigibles would in time stay in the air a year at a time, only going into hangars for repair purposes; mail, freight, passengers, and supplies being transferred from smaller aircraft while the dirigibles are passing over cities on their routes. He thought that in the future every mile of railroad in the Country would be paralleled by a mile of air transportation routes that would cost about 1 per cent as much as the railroad system of transportation. The coming generation will be a part of aeronautics just as the present generation has become a part of automobiles, but the change from automobiles to aircraft will be far less difficult than the change from horseflesh to automobiles.

With the rest of the world coming to the United States for automobiles, there is no reason, according to Mr. Rickenbacker, why the same will not hold true for aircraft, and this would put the Country in such a strong military position that there would be little fear about future peace.

Mr. Moskovics introduced Judge Solon J. Carter, a former judge of the Marion County Superior Court, as an expert on automotive matters, he having served as receiver for several automobile companies. Judge Carter discussed the origin of the Constitution, pointing out that it represented a compromise of idealists and business men who had wisely avoided attempting to adopt a definite line of guidance for posterity. He thought that men were now so closely interested in business that they were not paying attention to the men now in politics, who are more interested in furthering their own ends than following the intent of the Constitution. He reviewed the history of the prohibition question. According to Judge Carter, after the war Americans who had been brought up on the idea that certain rights were theirs began to seek justification for violation of the law. They took the atti-



THEIR BRAINWORK AND LEGWORK WERE RESPONSIBLE FOR THE ATTRACTIVENESS AND THE NEWSINESS OF THE *Daily SAE*

The Members of the Staff Were F. E. Booth, Editor-in-Chief; H. M. Carroll, Business Manager; W. A. Moffett, Managing Editor; M. S. Morgan, Technical Editor; and D. M. Carson, Sports Editor

E. V. Rickenbacker

Arthur Brisbane

TWO OF THE SPEAKERS AT THE INDIANA SECTION DINNER ON MAY 30 TO THE VISITING MEMBERS OF THE SOCIETY

tude, successfully assumed before in our history, that the law was against common reason and deprived individuals of a common right and that they would not obey it. The United States has been challenged as never before in her history by men ordinarily law-abiding. He quoted Emperor Justinian to the effect that "A sovereign has not the power to enforce a law subjects will not obey." He felt that it was highly necessary for engineers to face conditions that challenge the fundamental rights and liberties of American citizens.

, C. F. Kettering, who Mr. Moskovics stated needed no introduction, announced that he had recently made a very interesting experiment. He had purchased a Stutz automobile. In discussing the economic factors in the automobile industry, he pointed out that it takes a foreign workman 30 times as long to earn an automobile as it does an American workman. He thought that prosperity means the volume of raw material turned into finished goods and that the purpose of the engineer is to facilitate this process. The difference between uncivilized and civilized people is the number of so-called luxuries; for food, shelter and clothing are necessary for both.

Mr. Brisbane did not read the speech that he had written for the dinner for, as he stated, it would be possible for everyone to read it in the morning papers anyway. He did, however, emphasize certain parts of his speech and mentioned various automotive engineering data which he thought most interesting, such as the number of explosions per second at 100 m.p.h., and which he would pass on to the millions of readers that his editorials reach. In his published speech Mr. Brisbane wrote in part

> You men that perfect mechanism for transporting human beings and their goods belong to the great class of emancipators. You are included among those that put an end to slavery. Slavery is of many kinds. Wilberforce and Lincoln helped to drive out slavery of the human body. The French Revolution freed millions of miserable serfs attached to the soil. The printing press and school teachers are working to end the worst slavery—that of ignorance and superstition.
>
> You engineers are working to free humanity from the original slavery laid upon the human race and upon all moving creatures by gravitation.

AERONAUTIC MEETING PLANS PROGRESS

Committee Arranges for Splendid Papers and Other Features at Philadelphia

With a determination to make the 1926 Aeronautic Meeting of the Society the greatest and best ever held, Chairman W. B. Stout and Paul Henderson, Glenn Martin, Ralph Upson, E. P. Warner, and J. E. Whitbeck, members of the Com-

NATIONAL MEETINGS CALENDAR

AERONAUTIC MEETING
Bellevue-Stratford Hotel, Philadelphia—Sept. 2 and 3

PRODUCTION MEETING AND EXPOSITION
Hotel Sherman, Chicago—Sept. 21-23

TRANSPORTATION AND SERVICE MEETING
Copley-Plaza Hotel, Boston—Nov. 16-18

TRACTOR MEETING
Chicago

ANNUAL DINNER
New York City—January, 1927

ANNUAL MEETING
Detroit—January, 1927

mittee, have already succeeded in scheduling a number of noteworthy events.

Technical sessions, three in number, will be devoted respectively to engines, airplanes and air transport. An Aeronautic Banquet will be held on the evening of Sept. 2 and an inspection trip to the Naval Aircraft Factory will be made on the afternoon of Sept. 3. It is expected that many members will find it agreeable to enjoy in a single trip the Aeronautic Meeting, the National Air Races and the Sesquicentennial Celebration.

Among those who will participate in the engine session are Commander E. E. Wilson, U. S. N., who will speak on the Development of Air-Cooled Engines for Aircraft, and G. J. Mead, of the Pratt & Whitney Aircraft Co.

At the session on airplanes, Dr. Adolph Rohrbach of the Rohrbach Metall-Flugzeugbau, of Berlin, Germany, will present what promises to be an address of outstanding interest on the economical and rapid production of all-metal airplanes and seaplanes. Also participating in this session will be prominent engineers who will speak on Airplanes for Individual Ownership.

How I Fly at Night will be the subject of a paper to be presented at the Air Transport Session by W. L. Smith, pilot of the Air Mail Service. This session will include papers on the various equipment and methods applicable to the successful operation of commercial air lines.

QUAKERS HEAR ABOUT JOINTS

C. W. Spicer Describes Types of Universals at Pennsylvania Section Meeting

C. W. SPICER

Tracing the first reference to the universal-joint back to the Thirteenth Century, from 200 to 300 years before the time of Cardan and Robert Hooke, C. W. Spicer, vice-president and chief engineer of the Spicer Mfg. Corporation, described the erratic action of this peculiar piece of mechanism, its limitations and application to automotive vehicles and various types of construction at the monthly meeting of the Pennsylvania Section, which was held on the evening of May 11.

The meeting was held at Kugler's Restaurant, Philadelphia, where about 40 members of the Section and their guests joined in the members' dinner that preceded the meeting. Tellers appointed at the April meeting counted the ballots cast by the members for Section officers for the coming year and reported 91 votes each for the following, who were declared unanimously elected: Chairman, E. W. Templin; Vice-Chairman, A. G. Metz; Secretary, Adolph Gelpke; and Treasurer, T. O. Day.

PECULIARITIES OF THE UNIVERSAL-JOINT

While the purpose of the universal-joint is to transmit power around an angle, the action of the joint becomes very erratic if the angle exceeds a few degrees, said Mr. Spicer. If the angle is increased to a little less than 90 deg., at which the joint becomes inoperative, the driven shaft almost stands still while the driving shaft is rotating nearly 90 deg., and then suddenly jumps ahead of the driver to nearly 180 deg. and waits there, with only a very small movement, for the driver to catch up with it. He quoted an explanation of the relative motions of the two shafts and the theory of the cause, as given clearly by H. Vanderbeek before the Society in August, 1908. He also showed lantern slides of curves of the relative speeds of the driving and driven shafts as prepared by Earle Buckingham several years ago. When the joints are used in pairs, however, the irregular action of one corrects the variation in motion caused by the other and results in smooth running of the driving and driven parts.

At angles commonly encountered in motor-vehicle service, the efficiency of the universal-joint is so high that only delicate and accurate instruments can measure the losses, said Mr. Spicer, who illustrated applications of the joints with Hotchkiss drive and when torque arms are used.

Drawings were shown of numerous designs that were typical of hundreds of inventions which seem on paper to solve the problems of the universal-joint but which are of little use in actual practice; then the speaker turned to a discussion of the more conspicuous makes of joint that are offered to the motor-car trade at present, concluding with the Spicer products.

GREASE, OIL, FLEXIBLE-DISC, AND CUSHION TYPES

The Spicer Type-G joint, which is intended primarily for the use of grease as a lubricant and which has not undergone any radical change since 1904, is being manufactured in larger quantities than all other types put together, but to meet a demand for an oil-lubricated joint, the Spicer Corporation secured the manufacturing rights for the latest design of the F. W. Peters Allmetal joint and modified it to include S.A.E. Standard spline slip-joints, producing the Type-O joint. The feature that gives this a most important advantage is that the closure between the moving surfaces is made by saucer-shaped spring-tempered steel washers that provide a perfect oil-seal even after service equivalent to the life of the average car.

Non-lubricated flexible-disc joints have undergone development since 1907, the Goodrich Rubber Co. having been responsible for much of the improvement in fabric and rubber composition discs. Within the last 2 years the Spicer Corporation secured the marketing rights for an entirely new type of disc called the Spicer-Goodrich Long Life Disc. An initial wave is put into the fabric in the process of manufacture and the interior space is filled with a large core of live rubber so that the disc can buckle without injury. Another comparatively new type of joint is the cushion-ball universal, developed entirely within the Spicer organization. Eight rubber balls are enclosed within the coupling in such a way that four carry the load in one direction and the other four in the opposite direction, and when operating at an angle the balls have a slight rolling motion in their recesses. An especially important field for this type is in gasoline-electric vehicle service, in which the cushion balls absorb the variations in engine-crankshaft speed. This type is also made in modified form to provide a very short coupling.

Interesting applications of the Type-G and flexible-disc joints are made in the Brill rail-car and were explained briefly.

SERVICE PERSONNEL DEVELOPMENT

Finding and Training Good Men Discussed at New England Section's Meeting

Service management's big problem of hiring and developing shop mechanics of the right caliber was threshed out at length in a most interesting meeting of the New England Section on the evening of May 10, Chairman M. R. Wolfard presiding. This last meeting of the season was held at the Engineers Club in Boston and preceded by a members' supper as usual. Final action on the proposed amendments to the Section Constitution, By-Laws and Rules was taken by a vote of approval.

A. P. Welborn, vice-president and general manager of the Cadillac Automobile Co. of Boston, was the speaker of the evening and drew upon his long experience in service and sales work for the Cadillac and Packard companies in Boston and Detroit for a pleasing and informative talk. A lively

exchange of experiences and ideas pertinent to the subject occurred among the members in the prolonged discussion that followed Mr. Welborn's address. In both the address and discussion many references were made to high and vocational schools and colleges and universities as sources of supply for potential mechanics.

Qualities Desired in Service Men

Referring to the importance of the personnel in the service department, Mr. Welborn said that employes should reflect the character of the company and exemplify the purpose for which the business stands, that is, service to customers. The purpose should not be merely to make money but also to give honest value in work and merchandise. As the personnel is the mouthpiece through which the management speaks to patrons, extreme care must be taken in the selection and training of every employe, even the office boy; the important thing is not where he starts but where he will end.

Some of the important qualifications desired were listed and examples were given of their application to the business. These were honesty, loyalty, dependability, alertness, resourcefulness, possession of a proper objective, willingness to "pay the price," obedience, cheerfulness, willingness to learn, possession of backbone instead of wishbone, pleasing personality, desire to serve, equable disposition, understanding of the value of a promise, ability to put himself in the customer's place, readiness to assume responsibility, promptness on the job, and foresightedness, or the quality of being prepared.

If, when engaging men, an attempt is made to secure all of these qualifications in a single individual, it fails of course, but in making the effort one comes nearer the mark than if he has none to shoot at. The important objective, illustrated by Mr. Welborn by citing the Biblical story of Gideon and the Midianites (See Judges vi. and vii. if recollection is a bit hazy), is to surround oneself with a small number of dependable men who will follow instructions faithfully rather than with a large number of unreliable men. Another point is to treat men like human beings, to be accessible to them and to talk matters over in the organization.

Speaking of university graduates, he said that it is rather pitiful to have them apply to men in the service departments, most of whom have had little education, for mean jobs in the service station. Although they have had the advantages of higher education, they do not make use of them. To illustrate, in a salesman contest held recently by his company, the college men could not multiply $1,400 by $1.80 without using all of the ciphers, and then their answers invariably were wrong.

In conclusion, the responsibility of the management in setting the right example was pointed out. Many failures of the personnel are traceable directly to the heads of the business, who must inculcate the principles that are desired in their representatives.

Scares Away the Weak-Hearted

Asked by K. T. Brown to tell the best ways of hiring the right kind of men, Mr. Welborn said that time is well spent in trying verbally to make the applicants realize the arduous nature of the work, to scare those lacking in grit into quitting before they are hired. Even then, out of a dozen hired perhaps only one amounts to much. Boys who are taken when young and molded make the better material.

Mr. Fuller said that in general country boys are more likely to stick to the job and the organization than are city boys who have worked in various shops, and that 21 1/5 per cent of the boys in his service department had been there 5 years or more, several as long as 13 or 15 years. V. A. Nielsen said that when the Franklin Union opened an automobile instruction course more than 20 years ago he obtained a good crew of helpers from it and found that men who would take an all-winter course amounted to something. Along this line, E. O. Wheeler suggested that more should be done in Boston with the trade and practical art schools and Mr. Fuller stated that his experience with Brighton High School boys had been gratifying.

Sending men from shops in the smaller towns to a large city for intensive training often spoils them and they will want to return to the city, observed F. E. H. Johnson, who said that, even if $75 a week were offered, enough good mechanics could not be secured. Another member suggested traveling instructors to go from town to town to teach the mechanics. In defense of the college graduate, Mr. Shoemaker said that if, after getting an education, he is willing to take a service-station job and puts it to good use, he will make a valuable man.

NEEDED MOTOR-VEHICLE IMPROVEMENTS

Southern California Section Discusses Major Troubles and Their Remedies

Experience, the great teacher, was called upon at the May 14 meeting of the Southern California Section for advice regarding how to obviate or remedy present faults and failures of the motor vehicle and how to assure its increasingly successful development. Representative members of the local automotive fraternity marshaled the facts of motor-vehicle performance as they know them, and analyzed present conditions and future possibilities for the benefit of the 124 members and guests who were in attendance. It was "ladies' night" at this last meeting of the season. The wives

Photo by Witzel
Eugene Power

P. H. Ducker

W. H. Fairbanks

R. W. Stewart

Four Contributors to the Automobile Improvements Symposium at the May Meeting of the Southern California Section

and sweethearts present added piquancy to the occasion, and this was enhanced by the fine musical entertainment provided by noted Mexican and other artists. Some of the important points developed by the principal speakers at the technical session are included in the following account.

Judging from the experience of truck builders within his knowledge who have experimented with engines having more than four cylinders, it was remarked by J. J. Canavan, president of the Canavan Motors Corporation, Los Angeles, that the four-cylinder engine appears best adapted to the demands of heavy-duty-truck service. He referred to needed improvements in oiling systems and in the development of power, mentioning also the provision on some recent heavy-duty trucks of seven speeds forward and two reverse speeds to afford sufficient flexibility on all occasions. He predicted more extensive use of worm-gear drive for passenger cars and that, as electric transmission lines become more generally available and facilities for charging storage-batteries are more generally distributed, an increasing number of passenger cars and motor trucks will be propelled by electric motors. He believes also that the steam boiler and the steam engine will be developed for motor-truck propulsion.

In the opinion of P. H. Ducker, superintendent of transportation for the Southern California Edison Co., a combined governing and braking system to control vehicle speed regardless of load or grade is desirable and would lessen highway depreciation. He advocated the provision of more comfortable seats for truck drivers and greater ease of operation of the controls, saying that these features are especially needed for motor trucks in the West, the drivers of which travel long distances and drive many hours continuously. As to light trucks and passenger cars, Mr. Ducker said that a carbureter is needed which will feed a predetermined mixture of fuel and air that has the highest efficiency, regardless of engine-speed and atmospheric conditions, although such a carbureter might require a definite change in the valve system. He thinks that the number of sizes of tire should be limited and that, after considering State laws, fuel cost and labor and material costs, it would be well to define a weight of truck that is still low enough to permit a pay load sufficient to warrant operation.

Improved Materials and Lubrication

Since Mr. Ducker's experience is that most motor-vehicle trouble is due to valves and to braking systems, and since valve trouble is influenced by the grade of gasoline that is used as fuel, he suggested that the activities of gasoline producers and valve-material manufacturers be coordinated in an effort to define what valve material will resist fuel effects best. Regarding brakes, he holds the opinion that more simple ways of changing brakes should be devised and that they should be made of a material that will resist heating effects and destructive water-action.

R. W. Stewart, deputy city engineer of Los Angeles, remarked that something akin to a social relationship exists between an owner and his car. As to the facility with which a car can be greased and oiled, if the process is made a reasonably agreeable one an owner is less likely to lose the feeling of pleasant companionship that he should have for his car and is more likely to retain a personal interest in that particular make of car. Therefore, Mr. Stewart believes it will pay car builders to make greasing and oiling simple and easy.

Other possibilities of improvement suggested by various speakers during the progress of the discussion included the general use of conduit to protect the wiring system, a less crude breaker-device to obviate burning and pitting at the contacts, properly designed headlights, and radiators that will take care of a wider range of starting conditions.

At this meeting, Eugene Power, superintendent of automotive equipment for the Union Oil Co. of California, was installed as Chairman for the ensuing year. The meeting was an enjoyable and profitable one, and many of those present expressed their appreciation of it to Ethelbert Favary, the Secretary of the Section, who arranged it.

HOW FLEETS ARE MAINTAINED

Milwaukee Section Celebrates Armitage's Return and Hears Wotton Paper

Celebrating the return of Chairman J. B. Armitage to health and duty the Milwaukee Section held a very successful dinner and technical meeting at the Blatz Hotel, Milwaukee, on May 5. Mr. Armitage, in reply to the cordial words of welcome that were offered by G. W. Smith, chairman of the meeting, expressed keen regret that he had found it imperative to be absent from Milwaukee during the greater part of the Section's administrative year but congratulated the officers for having directed affairs in a very creditable manner.

Secretary Wollensak, on behalf of tellers F. M. Young, J. J. Goetz, and Louis Reinhard, reported the unanimous election by the Section members of the following officers for the coming year.

Walter S. Nathan	Chairman
J. B. Armitage	Vice-Chairman
G. C. Appel	Treasurer
A. C. Wollensak	Secretary

Chairman-elect Nathan expressed his determination during his tenure of office to assure the Section of a very active and prosperous year. He called especial attention to his plans to have all meetings arrangements prepared well in advance.

40,000,000 Miles per Year

E. Wotton, superintendent of equipment, Chicago Motor Coach Co., spoke very interestingly on Motorcoach Maintenance. He stated incidentally that at present the company with which he is connected, and the allied companies in New York City and St. Louis, are operating approximately 1100 motorcoaches with a mileage of about 40,000,000 miles per year. Approximately 420 motorcoaches that are housed in four different garages, besides the central repair shops, are operated by the Chicago company and Mr. Wotton's address was based upon his experiences in connection with this operation.

The garage superintendents are held responsible for the mechanical condition of the equipment in their respective divisions; they report directly to the superintendent of equipment so that each division is on a competitive basis. Accurate records are maintained by each division and are co-ordinated by the chief equipment clerk who is able to make comparative statements.

Inspection Held Important

All motorcoaches are subjected to inspection every 2500 miles. During these inspections, units are examined on a regular routine system, defective ones being removed and replaced by units that have been overhauled. The defective units are returned to the central repair shops for needed attention.

Oil and gasoline consumption averages are referred to as an excellent indication of the mechanical condition of the vehicle. Accurate records in this regard show the inspector where special attention is necessary. Proper lubrication is an important item closely associated with each inspection.

Each garage has an auxiliary stockroom in which all parts are carried on a maximum and minimum basis, but not in large quantities. For small parts, the minimum number to be carried is placed in a small canvas bag; thus the storekeeper is enabled to determine when the supply has reached the minimum and when he should order new parts from the central stores.

Garage Construction Requirements

In the construction of garages 350 sq. ft. per motorcoach and 1 inspection pit for every 20 vehicles are provided. Indirect heating systems are in favor, especially in view of the advantage of circulation, also the possibility of supplying

heat underneath the engines where it is most beneficial in extremely cold weather. Good ventilation is derived from this system during summer operation.

Approximately 100 men are employed at the central repair shops; about 1 man for 4 motorcoaches. In the central shops an allowance of 100 sq. ft. of floor space for each vehicle is found sufficient.

Maintenance costs can be classified under two main headings, labor and material. A daily material report is issued by the stores department and shows, on a cumulative basis, the cost of approximately 30 classifications of material.

Weekly personnel establishment reports suffice to show how the labor costs are running.

At the conclusion of Mr. Wotton's presentation practically every member present participated in a very profitable discussion.

PRODUCING MOTOR FUEL FROM COAL

Fieldner Addresses Joint Meeting of Chicago Section and Western Engineers

The Chicago Section's last monthly meeting of the season was held jointly with the Gas Section of the Western Society of Engineers on the evening of May 17 in the rooms of the latter society in the Monadnock Building, Chicago, with C. A. Snerr, chairman of the Gas Section, presiding. The speaker of the evening was A. C. Fieldner, chief chemist of the Bureau of Mines Experimental Station, at Pittsburgh, whose subject was Gasoline Substitutes from Coal. Considerable discussion, participated in by members of the two societies, followed the presentation of the paper.

Mr. Fieldner prefaced his address with a caution against assuming that he was an alarmist and was spreading propaganda that our petroleum will all be consumed in a year or two and that we shall be compelled to resort to coal products for driving motor vehicles. He then reviewed briefly the known petroleum and coal resources of the Country and followed this with an explanation of the methods developed and a description of the plants built for deriving gasoline and other internal-combustion-engine fuels from coal.

Four Methods Now Available

Four possible methods available today for converting coal into liquid fuel are (*a*) high-temperature carbonization of coal in by-product coke ovens or in gas retorts, by which process from 3 to 4 gal. of light oil is obtained from 1 ton of coal; (*b*) low-temperature carbonization, which is undergoing experimental investigation on a large scale in this Country and abroad and which gives larger yields of crude petroleum substitute and similar yields of light oil suitable for automotive fuel; (*c*) hydrogenation of coal by the Bergius method, whereby 1 ton of petroleum-like liquid fuel can be obtained from 2 or 3 tons of coal, and (*d*) synthetic methods of making volatile liquid-fuels from gases that, in turn, are made from coal, these liquid fuels being alcohols, methanols, so-called synthol, and so on.

Only the first of these methods is an existing commercial process that is providing motor fuels, of which benzol has especially desirable anti-knock characteristics. If the entire annual production of 570,000,000 tons of coal were treated by this process, said Mr. Fieldner, it would give only 14 or 15 per cent of our total motor-fuel requirement.

By carbonizing the coal at approximately between 1100 and 1200 deg. fahr. instead of from 1800 to 2000 deg., about three times as much tar is produced, that is, from 20 to even 35 gal. per ton, and it resembles petroleum in many respects. In addition, from 1 to 2 gal. of light oil can be scrubbed from the gas. Experiments have been made whereby from 18 to 20 per cent by weight of the tar has been converted by a cracking process into light oil suitable for automobile fuel; that is, roughly 4½ gal. per ton of coal. A total of 6 gal. can therefore be expected from 1 ton of coal by the low-carbonization method.

The Hydrogenation and Synthesizing Processes

The hydrogenation process consists in mixing pulverized coal with oil or coal tar to make a thick paste, which is pumped into a steel autoclave containing hydrogen, under a pressure of about 150 atmospheres, and heating to about 750 or 800 deg. fahr. Under these conditions, the coal is converted largely into liquid compounds, the yield from an experimental plant at Mannheim, Germany, being about 140 gal. of crude oil per ton of gas coal. On fractionation and distillation, this oil yielded 40 gal. of motor fuel, 50 gal. of Diesel-engine oil, 35 gal. of fuel-oil, and a pitch residue of about 10,000 cu. ft. of gas.

Much interest has been created in the last year by the synthesizing of alcohol from gases in Germany, said Mr. Fieldner, by which method hydrogen and carbon monoxide are heated in an autoclave, or pressure tube, to 750 or 800 deg. fahr. under a pressure of from 150 to 250 atmospheres in the presence of a catalyst, which is said to be zinc oxide. A water-gas machine of 1,000,000-cu. ft. capacity should produce about 2500 gal. of wood alcohol, or methanol, which should be equivalent to from 1250 to 1560 gal. of gasoline. However, methanol does not blend with gasoline and is not suitable alone for use in present engines.

By a similar process but using iron impregnated with an alkali as a catalyst, Professor Fischer, at Mulheim, Germany, obtained a mixture of substances which he called synthol, having distillation characteristics similar to those of gasoline, and which would operate in internal-combustion engines and blend with either benzol or alcohol. A laboratory yield of about 30 per cent in British-thermal-unit equivalents was obtained from the gases used.

Following the descriptions of the processes, Mr. Fieldner showed slides of the plants and apparatus used in the application of the different methods.

HOW AIRCRAFT PILOTS NAVIGATE

Aircraft Position-Finding Methods and Means Described to Dayton Section

Bradley Jones

Aerial navigation is the art of utilizing all possible aids to enable aircraft to accomplish its mission efficiently under adverse as well as under favorable conditions, according to Bradley Jones, of the engineering division of the Air Service, McCook Field, who delivered the principal paper at the meeting of the Dayton Section that was held May 12 in the auditorium of the Engineers Club, Dayton. He said also that such navigation implies selecting the altitude having the best meteorological conditions, such as visibility, direction and velocity of the winds and the like, and is not merely the flying of the most direct course. The evening technical session followed a dinner at which Victor Showalter, also from the aerial-navigation branch at McCook Field, gave a talk on the various aerial instruments used at present on aircraft to enable and to facilitate its navigation.

Navigation of any sort presents the two problems of ascertaining position on or with respect to the earth's surface and of maintaining a direction, Mr. Jones continued. If the direction of movement is known, the determination of position becomes simplified.

The position of a ship at sea is ascertained by observations of the sun or the stars. After allowance is made for esti-

mated currents and the expected drift due to wind, a course is set that should bring the ship to its destination. A device called a "log" indicates the number of miles the ship travels ahead through the water, and a position can be deduced at any time by reading the log and assuming that this distance has been traveled along the set course except for drift and current; but this "dead-reckoning" is subject to considerable error. Whenever a position is found by astronomical observations, it is assumed to be correct and the discrepancy between the dead-reckoning position and that found by sextant observation is usually attributed to "current," which includes not only the difference in position due to the motion of the waters but also errors due to imperfect steering, improper allowance for compass error, drift and inaccurate logging.

In the air, navigation by dead reckoning is extremely difficult when out of sight of land, because of the variability of the air currents or winds. At sea, the movements of the water are well known and have been charted; but currents in the air are not constant, varying from hour to hour and differing with changes in altitude, and the problem is therefore more complicated. On ordinary cross-country flights, the drift of an airplane can be measured by any one of several sighting devices. Knowing the angle of drift, the course of the machine is altered, "crabbing" into the wind so that a correct course over the ground is flown. Even on cloudy days rifts or holes in the clouds usually exist through which glimpses of the ground can be had that are sufficient for measuring drift, but if clouds obscure the ground entirely, drift measurements from an airplane are impossible.

Further Essentials for Navigating

An aviator needs a good compass to enable him to fly a straight course over land, and he must be kept informed of his drift so that this straight course will be the correct path to his destination. Lacking such information, he is forced to follow railroads, highways and rivers and consequently must travel a circuitous route. Compass readings and knowledge of drift are needed also when flying over water. Since objects on which to "sight" are absent, smoke bombs or flares are carried and these are dropped from the airplane whenever a drift measurement is desired.

Sextant observations are made in much the same manner as from ships and, if the airplane is low enough so that the sea horizon is usable, the same degree of accuracy is obtainable. When clouds or haze obscure the horizon, an artificial horizon is used. The accuracy of these "shots" is much less than that obtained by using the true horizon, but probably it is of a higher order than is the accuracy of dead-reckoning.

NORTHERN CALIFORNIA MEETINGS

Lahm Talks on Commercial Aviation at Monthly Meeting—Weekly Luncheons

Motion pictures of aerial bombing operations were an interesting accompaniment of the address on Commercial Aviation by Col. F. T. Lahm, member of the National Aviation Contest Committee, scheduled for the monthly meeting of the Northern California Section on the evening of May 12 at the Engineers Club in San Francisco following the customary members' dinner.

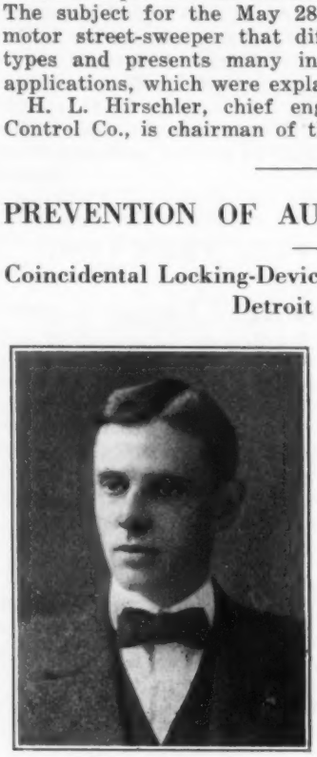
During the month a mail vote of the members was taken on the proposal of the Southern California Section to hold a joint technical and sports meeting of the two bodies at Del Monte about the middle of either July or August. Results of the vote have not been reported to THE JOURNAL at this writing.

The lively interest that the members of the Northern California Section take in automotive engineering affairs is made evident by the holding of weekly luncheon meetings at the Engineers Club. These take the form of informal discussions of specific topics. On May 7 S. L. Minier, of the Simplex Piston Ring Co., and M. A. Mock, of the Star Piston Ring Co., gave talks on special forms of piston rings. At the May 14 luncheon Fred Keller, service manager for the Stutz Motor Car Co., told of the new design features of the 1926 Stutz cars. The May 21 luncheon meeting was devoted to hearing Frederic von Rossen Hoogendyk, American representative for the Colo Diesel engine, describe this engine, which is reputed to be the leading German small-size Diesel. The subject for the May 28 luncheon was the new Lund motor street-sweeper that differs radically from the usual types and presents many interesting design features and applications, which were explained by G. E. Lund.

H. L. Hirschler, chief engineer of the Horace Remote Control Co., is chairman of the Luncheon Committee.

PREVENTION OF AUTOMOBILE STEALING

Coincidental Locking-Devices Analyzed for Buffalo and Detroit Sections



C. B. VEAL

An alarming increase in the number of thefts of automobiles and the consequent continuously increasing rates of insurance against such thievery urgently necessitate more effective and more drastic means and measures of theft prevention if the evil is to become minimized, according to the recent paper by C. M. Manly and C. B. Veal on Coincidental Locks, read by Mr. Veal at the meeting of the Buffalo Section that was held on May 18 and also at the May 20 meeting of the Detroit Section. Statistics show that 57,331 automobiles were stolen in 28 cities in 1924, varying downward in number from 10,064 stolen in New York City alone, and more recent data afford further proof of the serious nature of this phase of outlawry in regard to its effect upon the car-owner, the car builder and the insurance companies. The paper was profusely illustrated and, in each instance, its presentation elicited valuable discussion of the salient features.

Man's method of seeking security from thieves has always been to provide locks and to improve them, and such procedure naturally comes in for first consideration as a preventive of automobile theft. Continuing, Mr. Veal said that all statistics on the subject clearly point to the fact that any locked car is practically immune to theft if the lock itself has merit, and he outlined the early forms of locking device and their development. But as has all too frequently been true of carefully engineered affairs, the speaker asserted, the application of the laws of nature to automobile locks was correct and the laws of human nature were misunderstood and wrongly appraised. The finest lock is of no avail unless used, and most locks that have been provided have not been used.

In proof of the non-use of locks installed on cars, Mr. Veal cited the following authenticated statistics. A recent survey by a dealer in New York showed that, of the 100 cars examined, only 30 per cent were locked adequately. A similar survey in Buffalo of 67 cars that were equipped with transmission locks resulted in finding only 8 properly locked. An inspection of 98 Ford cars equipped with accessory steering-gear locks revealed that only 9 were locked. All the statistics collected by the Underwriters and by other national agencies show that about 85 per cent of the cars equipped with approved locking devices are habitually left unlocked when parked.

Creation of the Coincidental Lock

Commenting on the foregoing citations, Mr. Veal remarked that the coincidental lock came into being specifically to meet this situation. Drivers, almost universally, turn-off the ignition switch when leaving a car unattended, and this is about the only operation that all drivers can be depended upon to perform. Hence, the coincidental lock seeks by one means or another to take advantage of this fact by making the locking and the ignition functions interrelated so that it is impossible to open the ignition-circuit switch without either previously or simultaneously locking the car.

He then went on to state and to comment upon the Underwriters' specifications for coincidental locks. The first requirement for the latest type of such lock, said Mr. Veal, rightfully recognizes the necessity for making any locking device conveniently accessible to the driver. Inaccessibility has been the stock argument against transmission locks as a class, when these locks are located at the floor-boards. But it is not sufficient to make the locking operation easy to perform; conditions must be created such as to make avoidance of performance difficult. The coincidental lock is intended to accomplish this without requiring of the driver anything more than he has been accustomed ordinarily to do when stopping the engine; that is, to shut-off the ignition.

Ideal Locking-Device Specification

Mr. Veal suggested that an ideal specification might be advisable, to serve as a standard for judging all coincidental locks. Accepting the Underwriters' Laboratories' rating of locks as theft retardants, he specified the following conditions and stated that any lock which fulfils them all should meet most of the objections that have been raised against coincidental locks:

(1) The lock should be conveniently, easily and positively operated, "on" or "off," under all climatic conditions and in darkness as well as in daylight

(2) Either a key should not be required for unlocking, or locking should be accomplished only coincidentally upon removal of the key, else the very purpose of the lock is partly defeated

(3) Slight chance should exist for accidental operation of the lock while the car is in motion

(4) No lock distinctly similar to the ordinary ignition switch in location or operation should simultaneously lock any control element of the car with the breaking of the ignition circuit

(5) For quick action in emergency, while the car is in motion, means should be provided for stopping the engine that is simple and easy of operation and such that throwing "on" is the exact opposite of throwing "off" and vice versa

(6) While "coasting" with ignition "off" is not to be sanctioned, the driving public still demands some means by which to shut-off the engine when coasting; therefore, a coincidental lock should provide such means, preferably without disturbing the ignition

(7) Movement of the car under certain conditions, such as when in a public garage or when parked in the street in case of fire, should be permitted with ignition "off" and without leaving the key with the car

(8) The car should be locked so as to prevent it from being towed

(9) Locking the car should not prevent leaving the transmission in gear when the car is parked on a hill, or cramping the wheels against the curb when desired

(10) The entire mechanism of the lock should be simple, of rugged construction, of low cost, and easy to install

AVIATION DEVELOPMENTS PROPHESIED

Metropolitan Section Hears Instructive Papers by Klemin, Black and Kendall

Prof. Alexander Klemin, director of the Daniel Guggenheim School of Aeronautics at New York University, in a most helpful and interesting paper presented before the Metropolitan Section at its May 20 meeting, described a number of developments that are noteworthy as radical aerodynamic departures from the conventional airplane. These included the slotted wing and flap for the increase of the maximum lift of an airfoil; the slotted wing and flap utilized as ailerons to improve the lateral control at low speeds; La Cierva's Autogyro; and Capt. G. T. R. Hill's tailless airplane.

After discussing in some detail and from an aerodynamic viewpoint the characteristics of various types of heavier-than-air craft, Professor Klemin summarized these desirable characteristics as follows: Wings so adjustable as to give high maximum lift when desired, yet retaining their utmost efficiency in normal flight; wings or adjustable wings that do not lose lift at the critical point; elevators that do not cease to be operative during the stall; ailerons that always provide rolling moment without excessive yawing moment; rudders that do not lose their power to overcome the yawing action of the ailerons in any flight condition; complete control beyond the stalling point; and ability to glide down at a steep angle, while maintaining the longitudinal axis almost horizontal and the vertical component of velocity at a moderate figure.

It is a remarkable thing, he said, that these desirable aerodynamic characteristics are being attained by three different methods of approach.

La Cierva's Autogyro, a comparatively recent foreign development, was described briefly from the structural and aerodynamic viewpoints and was said to be an extremely promising type of aircraft.

Capt. G. T. R. Hill's tailless airplane or Pterodactyl was said to be particularly interesting in view of its wonderful flying properties.

A Stimulating Period

Professor Klemin concluded his address that was very well received by members of the Metropolitan Section with the following conclusions and remarks:

> Sufficient has been said perhaps to indicate that we are on the eve of most remarkable developments in aerodynamics, which bid fair to increase immeasurably both the utility and safety of heavier-than-air craft. It may be permissible to hazard a few predictions.
>
> The advent of the Autogyro will spur on every designer of airplanes to achieve similar results with more conventional means. The Autogyro will pass through many improvements, achieve even better results, show its limitations and find its scope in the construction of machines for special purposes, such as perhaps landings in restricted city areas. It is unlikely that the Autogyro, in spite of its remarkable aerodynamic properties, will give the same efficiency or safety for regular flying as the stationary wing. Any sustaining surface that depends on rotation, on vertical oscillation of moving blades, on rubber shock-absorbers, or similar means will not ultimately challenge the supremacy of the fixed wing, provided the fixed wing can give the same measure of security at the stall and the same properties on steep descent. Moreover, it does not seem likely that the Autogyro will lend itself to the production of very large machines owing to the tremendous concentration of sustaining loads.
>
> The Handley Page slotted airfoil and the slotted flap will undoubtedly achieve recognition in view of the

(*Concluded on p.* 574)

COUNCIL SESSIONS AT SUMMER MEETING

THE sessions of the Council held during the Summer Meeting were attended by President Litle. First Vice-President Hunt, Second Vice-Presidents Nutt and Guernsey and Councilors Burkhardt, Chandler, Warner, and Winchester.

One hundred and seventy-three applications for individual membership were approved, also 14 grade transfers were made and 3 reinstatements approved.

The following appointments to membership on the Standards Committee, with Division assignments as indicated, were made.

F. E. A. Klein—Production Division
D. W. Oviatt—Screw Threads Division
Paul Weeks—Motorcoach Division

Motor-Vehicle-Fleet Operation and Maintenance

In compliance with the recommendation of the Special Committee on Motor-Vehicle Operation, consisting of F. K. Glynn, Chairman, R. E. Plimpton, John Stillwell, and C. B. Veal, the Council decided to establish a general committee to represent motor-vehicle-fleet operation and maintenance, as well as manufacturers' and dealers' service; to formulate policies and recommendations regarding research, standardization and production related to the operation and maintenance of motor vehicles; and also to cooperate with the Sections and the Meetings Committee of the Society in stimulating interest in operation and maintenance matters. This committee will report its findings and recommendations regarding research and standardization directly to the Council.

Standard Section Constitution, By-Laws and Rules

The 1926 edition of the standard Section Constitution, By-Laws and Rules, as revised during the last season by the 13 Sections of the Society, was approved. This edition of this basic document is the result of a thorough study that has been made during the last year by the Sections Committee, the Sections themselves and the Sections Department of the Society of the current needs of the Sections in the orderly and effective maintenance of their activities. Revision of the standard Section Constitution requires the approval of the Council of the Society. Amendments, such as these that have been made recently, take effect immediately after affirmative action of the Council and notice to this effect to the Section. Amendments of the standard Section By-Laws is also subject to approval by the Council and such amendment goes into effect 1 month after it has been announced at a regular Section meeting.

The only variation in the standard Section Constitution By-Laws and Rules, as between one Section and another under the recent revision, relates to automatic succession to the vice-chairmanship of a retiring chairman after a term of 1 year of office and to the time of the beginning of the Section administration year.

Street and Highway Safety

In connection with the reduction to practice of the recommendations of the National Conference on Street and Highway Safety, made in its 1924 and 1926 reports, the Council referred to the special committee consisting of President Litle and Past-Presidents Crane and Horning the matter of cooperating in various phases of the program, as requested by Secretary of Commerce Hoover. The specific matters on which the Society has been asked to cooperate are the study of causes of accidents and the design, construction and maintenance of motor vehicles. Various other associations and organizations have been invited to take part in this cooperative effort, among these being the Eastern Conference of Motor-Vehicle Administrators, the National Association of State Highway Officials, the National Automobile Chamber of Commerce, the National Research Council, the National Safety Council, and the American Automobile Association.

PRESENT LEVEL OF BUSINESS ACTIVITY

IN the last quarter-century all the speed limits of past eras, ancient and modern, have been exceeded. The Augustan Elizabethan, Napoleonic and Victorian eras have all been surpassed. How far, we can readily note in brief retrospect. Transportation and communication have been revolutionized by the motor car, the flying machine and the radio. The wealth of the world has increased beyond belief; that of the United States has quadrupled. High standards of living and new conveniences and comforts are enjoyed by increasing millions. Labor-saving machinery and scientific developments are speeding production and facilitating consumption. Education and understanding are moving as rapidly as invention; and through all this great material progress we see evidences of a greater sense of social responsibility, of higher ideals of life and its meaning. Commerce and culture, material achievement and spiritual advancement, are in step.

Our present high level of business activity is due to the return of buying power to the farmer, the boom in real estate, the activity in the motor industry, and the increasing volume of capital seeking employment. But back of these obvious factors are the strength of our position in world finance, our supply of gold, our great natural resources, our increased productive capacity, our new markets, and the constructive enterprise of our people. We have the money, the materials and the men—the combination spelling economic supremacy under a political régime that assures peace and order.

The material gain in the value of our foreign trade is only one of many reflections of the forces that have promoted world-wide economic recovery from the disaster of war and the post-war collapse. The recovery has made enormous strides in the last year. Most of the countries of Europe have succeeded in balancing their budgets and in stabilizing their currencies, and several have definitely resumed the gold standard. Physical rehabilitation has been accompanied by industrial and commercial reorganization. Trade routes and markets, both new and old, have been opened. Provision has been made for the settlement of international debts, and new loans have been made to finance industrial expansion. And, finally, confidence has been promoted by either the complete removal or the mitigation, in a greater or less degree, of the peril of war.

Both at home and abroad, however, much yet remains to be achieved before it can be truly said that the world's economic recovery is accomplished. The international financial situation is still abnormal. The bulk of the world's monetary gold is in the United States, and its redistribution will necessarily be retarded by the enormous program of debt payment which is contemplated. As long as this situation continues, to prevent, in this Country, the inflation that ordinarily follows a great increase in monetary stocks, will require unceasing vigilance.—From an address by F. H. Sisson, at Banquet of Trust Companies, New York City.

STANDARDIZATION ACTIVITIES

The work of the Divisions and Subdivisions of the S.A.E. Standards Committee and other standards activities are reviewed herein

BETHLEHEM STEEL CO. ENTERTAINS

Iron and Steel Division Members Are Guests of Company for 2-Day Meeting

A 2-day meeting of the Iron and Steel Division members was held on May 11 and 12 at Bethlehem, Pa., as guests of the Bethlehem Steel Co. The program included a Division meeting in the afternoon of the first day at the Hotel Bethlehem, dinner at the Saucon Valley Country Club, an inspection trip through the Bethlehem Steel Co.'s plant on the morning of the second day and an adjourned Division meeting at the Saucon Valley Country Club in the afternoon.

The suggestion of the metallurgical subcommittee of the General Purchasing Committee of the General Motors Corporation with regard to increasing the sulphur and phosphorus limits in the S.A.E. Steel Specifications 0.005 per cent was considered favorably, the consensus of opinion being that no injurious effects would result from the use of the higher limits and that increasing the limits would put the Society in a much stronger position technically. Final action was left to a letter-ballot of the Division members.

It was also suggested to change the S.A.E. Specifications to specify manganese limits of 0.30 and 0.60 per cent for all case-hardened steels to make the specifications consistent; to specify silicon limits of 0.15 and 0.30 per cent for all S.A.E. Steels, but final action was withheld pending a letter-ballot of the Division members.

The adoption of two low-nickel steels was proposed, the chemical compositions suggested being as follows:

No.	Carbon	Manganese	Phosphorus, Maximum	Sulphur, Maximum	Nickel
2015	0.10 to 0.20	0.30 to 0.60	0.04	0.045	0.40 to 0.60
2115	0.10 to 0.20	0.30 to 0.60	0.04	0.045	1.25 to 1.75

Submission of these steels to a letter-ballot of the Division members was approved. A complete account of the meeting will appear in an early issue of THE JOURNAL.

MOTORCOACH REGULATIONS

National Automobile Chamber of Commerce Holds Meeting on Uniform Regulations

The Motor Truck Committee of the National Automobile Chamber of Commerce is studying uniform regulations to be used by the several States and their political subdivisions as the basis for uniform regulations that are intended to govern the safety features of the construction of motorcoaches for operation within those territories. A general meeting was held in Detroit on May 6 to consider the problem of restrictive and conflicting regulations now in force and to plan a definite organization and course of action in connection with the further study of the subject. One point brought out was that many operators purchase the chassis from the motorcoach builder and obtain the body from a local shop, thus making the cost of the latter unnecessarily high. It was felt that with uniform regulations throughout the Country the motorcoach builders can turn out the bodies for their chassis on a production scale without danger of conflicting with the regulations under which their customers will operate the vehicles.

It was felt that the best starting point in drafting a suggested specification is to use the S.A.E. Recommended Practice for Motorcoach Specifications printed on p. M51 of the S.A.E. HANDBOOK for further study by a Committee to be organized, representing among others the National Automobile Chamber of Commerce, the Motor Vehicle Conference Committee, the American Automobile Association, the conferences of Motor Vehicle Administrators in the several States, the Society, and other major groups that will be directly interested. A temporary Committee of five was appointed at the meeting to make a preliminary review of the S.A.E. Specifications and to suggest such modifications or additions as seemed desirable. It was recommended to omit the items of Visibility, Handles, Ventilators, Footboards, Wheel Housing, and Fenders and to include items for body width, length and head room; door heights; tail lamps; marker lamps for width; and possibly a color scheme for destination lights. It was also recommended that specifications be drafted for all types of motorcoach covered by the S.A.E. Nomenclature inasmuch as the present specification is intended only for the single-deck city-type of vehicle. The National Automobile Chamber of Commerce is proceeding with the organization of a general committee to handle this subject.

CABLE COLOR CODE PROPOSED

Automobile Wiring Subdivision's Report to the Electrical Equipment Division

The Subdivision on Automobile Wiring, at a meeting held in Detroit on April 13, proposed for the consideration of the Electrical Equipment Division three color schemes for identifying automobile cable. The color schemes proposed are as follows:

PASSENGER-CAR CHASSIS-WIRING COLOR SCHEME FOR USE WHERE CABLE IS BOUGHT IN COILS

RED (Unprotected Live Wires)

Generator to Cut-Out or Regulator
Cut-Out or Regulator to Ammeter
Ammeter to Battery
Ammeter to Overload Breaker or Fuse
Low-Tension or Primary Ignition
All Other Unprotected Live Wires

YELLOW (Protected Live Wires)

Horn Feed Wire
Signal-Lamp Switch Feed Wire
Body-Lighting Switch Feed Wires
Protective Devices to Lighting Switches
All Other Protected Live Wires

PASSENGER-CAR CHASSIS-WIRING COLOR SCHEME FOR USE WHERE CABLE IS BOUGHT IN FORM OF HARNESS

RED (Unprotected Live Wires)

Generator to Cut-Out or Regulator
Cut-Out or Regulator to Ammeter
Ammeter to Overload Breaker or Fuse
All Other Unprotected Live Wires

RED WITH YELLOW TRACER

Low-Tension or Primary Ignition

RED WITH BLACK TRACER

Ammeter to Battery

YELLOW (Protected Live Wires)

Horn Feed Wire
Signal-Lamp Switch Feed Wire
Body-Lighting Switch Feed Wires
Protective Devices to Lighting Switches
All Other Protected Live Wires

BROWN WITH BLACK TRACER

Lighting Switch to Junction Block (Parking Lamp)
All Ground Connections (except Battery Ground)

BLACK

Lighting Switch to Tail-Lamp

BLACK WITH RED TRACER

Bright Head-Lamps (or Upper Beam)

GREEN

Dim Head-Lamps (or Lower Beam)
Signal-Lamps (Switch to Lamp)

MOTORCOACH AND TRUCK CHASSIS AND BODY-WIRING COLOR SCHEME[1]

RED (Unprotected Live Wires)

Generator to Cut-Out or Regulator
Cut-Out or Regulator to Ammeter
Ammeter to Battery
Ammeter to Overload Breaker or Fuse
Low-Tension or Primary Ignition
All Other Unprotected Live Wires

YELLOW (Protected Live Wires)

Horn Feed Wire
Signal-Lamp Switch Feed Wire
Body-Lighting Switch Feed Wires
Protective Devices to Lighting Switches
All Other Protected Live Wires

BROWN WITH BLACK TRACER

Generator to Cut-Out or Regulator (Ground)
All Ground Connections (except Battery Ground)

BLACK

Bright Head-Lamps (or Upper Beam)
Body-Lamp Feed Wires (Switch to Lamp)

BLACK WITH RED TRACER

Dim Head-Lamps (or Lower Beam)
Tail-Lamp

GREEN

Signal-Lamp (Switch to Lamp)
Signal-Lamp (to Indicator or Pilot)

At the meeting of the Electrical Equipment Division on April 5 the report of the Subdivision on Automobile Wiring, which had been drawn up at a meeting on Jan. 12, was discussed and the suggestion made that a color code employing two, three, four, and five colors would be desirable in order that a manufacturer could use any number of colors, depending upon his individual requirements, and still conform to the standard. The report was consequently referred back to the Subdivision for reconsideration. At a meeting of the Subdivision on April 13 this suggestion was carefully considered, but the consensus of opinion was that such a color code would be confusing for anyone attempting to check up the wiring of a particular car as it would not be known which color code had been used by the builder. It was, therefore, considered preferable to submit a simplified code using only two colors. It is thought that when the code has been generally adopted in practice the Electrical Equipment Division could add additional colors.

Those present at the Subdivision Meeting were W. S. Haggott, of the Packard Electric Co., chairman; W. B. Churcher, of the White Motor Co.; G. A. Delaney, of the Paige-Detroit Motor Co.; and B. M. Smarr, of the General Motors Corporation.

[1] It is assumed that motorcoach and motor-truck builders will buy cable in bulk.

PNEUMATIC TIRE RIMS

Tire and Rim Division Recommends Adoption of Sizes for Low-Pressure Tires

Since the introduction of low-pressure or so-called balloon tires for passenger cars, the Society has been working to establish a standard for sizes to keep them at the minimum number. The first material step in this direction was the approval and publication in the S.A.E. HANDBOOK in February, 1924, of a list of five low-pressure tire cross-sections with their corresponding rim diameters and widths as General Information in anticipation that car builders would be guided as much as possible by such a list. Developments in low-pressure tire design since then have, however, led to a materially increased number of sizes, and after surveying the situation the members of the Division held a meeting in Detroit on May 7 at which it was decided to recommend the adoption of a restricted list of rim sizes as S.A.E. Recommended Practice without including a recommendation regarding the tire cross-section diameters, as it is believed that interchangeability of tires on wheels, which is the main purpose of this standardization, will result. It was also voted to recommend that the term "low-pressure tires" be used instead of balloon tires. The rim sizes included in the recommendation are given in the accompanying table. As the trend of practice seems to be toward the 20-in. diameter wheel in many cases, it is possible that the 20 x 4-in. rim size will be included.

PROPOSED RIM SIZES FOR LOW-PRESSURE TIRES

Nominal Rim or Tire-Seat Diameter, In.	Rim Width, In.	Tires Regularly Mounted on Rims[2]
		29 x 4.40
21	3½	30 x 4.75
		30 x 4.95
21	4	31 x 5.25
		30 x 5.77
20	4½	32 x 6.00
		32 x 6.20
		33 x 6.00
21	4½	33 x 6.20
21	5	33 x 6.75

[2] Tire sizes are not a part of the recommendation but are given to show the regular tire sizes of each rim specified.

It was also recommended that the detailed dimensions of the several rims should be in accordance with the standards of the Tire & Rim Association of America and published in the S.A.E. HANDBOOK as General Information rather than as S.A.E. Standard as at present. No action was taken regarding high-pressure tires or rims, as they have been superseded almost entirely by low-pressure tires on passenger cars. Neither was any action taken by the Division on low-pressure tires or rims for motorcoaches, as it was felt that they are still subject to too much development to make a definite recommendation.

The report of the Division was submitted to the Standards Committee meeting of the Society at French Lick Springs on June 1 for discussion and approval. The action taken at this meeting is reported on p. 530 of this issue.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

PROGRESS IN RESEARCH ACTIVITY

Some of Society's Projects Are Completed While Others Develop New Issues

Since the first of the year, the Society's research work has forged steadily ahead and now is at the stage where definite and marked progress can readily be conceded. Some projects have been completed; some have run through the course set and new schedules have been prepared for them; still others are progressing evenly toward a more distant goal. To give a clear picture of this activity, this brief, unified outline is presented. More detailed information and the valuable technical data obtained from the investigations made are incorporated in various papers presented verbally at the Summer Meeting and in printed form in this and other issues of THE JOURNAL.

In its study of fuels, the Society has enjoyed, as in the past, the cooperation of the American Petroleum Institute, the Bureau of Standards and the National Automobile Chamber of Commerce. Three subjects have been included in the research: motor-fuel performance, methods of measuring gasoline-volatility and crankcase-oil contamination.

In the field of motor-fuel performance, engine-starting conditions have for some time received the major attention. Since the last report was made to the Society, at the Annual Meeting in January of this year,[1] the effect of engine-speed on starting has been investigated. Tests have been made to determine the time to start, at engine-speeds of 80, 100, 150, and 200 r.p.m., for various fuel-air and compression ratios. Some experiments on the effect of atomization and vaporization on starting have also been carried out.

With the completion of these experiments, the question arose as to which of the many fuel-performance problems awaiting solution should be selected for immediate study. An investigation of fuels and engines as regards acceleration and performance during the warming-up period at once suggested itself. The American public is notoriously insistent on quick acceleration. Carbureters are therefore commonly set to provide mixtures so rich as to involve fuel-waste in normal running. Because acceleration looms so large in both utility and economy, and because it is the next logical step after starting in a study of fuel-performance, it was selected as the subject of further investigation. The research is to be concerned mainly with the lower part of the distillation curve, the 5, 10, 20, and 50-per cent points having been chosen for particular attention.

DETONATION AND GASOLINE VOLATILITY TO BE STUDIED

Scarcely an issue of any technical magazine containing references to internal-combustion engines appears without some allusion to detonation. Experimentation in connection with this phenomenon is increasing daily; yet such research does not yield adequately informative results because of the variance in the methods used to determine detonation. A recent issue of an American periodical reported an investigation into the knock-suppressing qualities of 59 different chemical substances.[2] Almost simultaneously, an English magazine published an account of similar experiments carried out at the Air Ministry Laboratory of the Imperial College of Science and Technology.[3] In the first research, the results were arrived at by the Midgley bouncing-pin method and consisted of a comparison of the anti-knock characteristics of the chemicals with those of tetra-ethyl lead; in the second, the sealed tube and the E-35 type of Ricardo variable-compression engine were used, and the highest useful compression-ratios of the substances studied were found.

Obviously, to obtain the utmost value from such research, a thorough understanding should be had of the procedure followed. A new phase of the Cooperative Fuel-Research is the study shortly to be entered upon of the methods now in use of measuring the anti-detonating qualities of motor-fuels.

A division of the Cooperative Fuel-Research to which considerable study has been, and will be, directed is the development of laboratory test-methods for measuring fuel volatility. The object of the work is to discover some way of evaluating gasoline more nearly in terms of engine-performance than do the means now commonly in use. One procedure evolved as a result of the investigation is designed to test the volatility of a fuel for starting purposes; with the other, so far as present experiments indicate, measurements may be made of fuel-volatility over the whole range from 0 to 100 per cent evaporation. Further efforts will be directed toward perfecting the two methods and determining their limits of usefulness. Additional engine-starting tests will probably be made, the results of which may be correlated with the data obtained with the laboratory apparatus for measuring fuel volatility. Brief reports on this phase of the Cooperative Fuel-Research were made at the Annual Meeting and published in the April issue of THE JOURNAL,[4] and at the Summer Meeting in a paper by T. S. Sligh, Jr., entitled Gasoline Testing.

CRANKCASE-OIL SURVEY ENJOYS NATION-WIDE SUPPORT

In the investigation of contaminated crankcase-oil, samples of used oil have been collected from cars operating as far west as San Francisco and as far east as Boston; as far north as Minneapolis and as far south as New Orleans. The cooperation of more than 60 service-stations, representing about 10 car builders, has given to the survey this nation-wide scope. Two collections, resulting in the obtaining of 700 samples, were made, one in the 1924-1925 season and one just completed early this spring. The samples were analyzed at the Bureau of Standards, and the data so obtained arranged and interpreted by the Research Department. The results of the completed project are contained in the paper entitled Causes of Wear and Corrosion in Engines, presented at the Fuels and Lubricants Session of the Summer Meeting.

In the study of headlighting, as well as of fuels and other subjects, the Society has had the benefit of strength that comes with union. During the last 5 months, the Society, acting in cooperation with the Illuminating Engineering Society, through the agency of a Joint Steering Committee on Headlight Research, has made definite progress in this field.

In a motion passed at its first meeting on Jan. 12, 1926, the Joint Committee stated that its first objective was

> To stimulate and guide experimental research directed toward the determination of the most satisfactory methods of automobile headlighting and, in accord-

[1] See THE JOURNAL, February, 1926, p. 147.

[2] See *Industrial and Engineering Chemistry*, April, 1926.

[3] See *Engineering* (London), April 9, p. 475; April 16, p. 509; April 23, p. 542; and April 30, 1926, p. 575.

[4] See THE JOURNAL, April, 1926, p. 393.

ance with the results of the research, to formulate a code of recommended practice with respect to headlight equipment, adjustment and use.

At that time a program was formulated consisting of four main topics that can be summarized briefly as follows:

(1) Literature. The collection of data now available on the illumination required for the visibility of substantial objects under conditions analogous to those of the headlighting problem

(2) Fundamental studies on visibility and illumination as related to the headlighting problem

(3) Status of the art

(4) Symposium of opinion on ideal headlighting

At the last meeting of the Joint Committee on May 4, Dr. Percy W. Cobb presented a report entitled Visual Fundamentals in the Headlighting Problem, in fulfillment of Part 1 of the program. At the same time, A. W. Devine gave an account of extensive observations made in the State of Massachusetts on the condition of head-lamps in use. In his talk on Common Troubles with Present Headlighting Equipment, delivered at the Headlighting Symposium of the Summer Meeting, Mr. Devine summarized the main points of his findings. This work constitutes an important contribution to Part 3 of the program. Mr. Devine will continue his studies in this field.

Headlighting Symposium Evokes General Interest

Part 4 of the program is designed to bring to active expression the opinions of car builders and others on the subject of headlighting. The symposium is to take the form of the demonstrating of cars equipped with combinations of lighting sources arranged to supply the best lighting system practical in the opinion of the individual or organization submitting the respective cars. The purpose is to compare lighting distributions, not lamps, and as many of these as may be necessary to secure the desired result.

So that those desiring to participate may easily obtain the tools with which to work, a form of headlight test-equipment has been developed and specifications for it drawn up. At the Headlighting Symposium of the Summer Meeting, R. N. Falge described the development of this equipment, its operation and advantages. Following this, J. H. Hunt explained certain typical light-distributions that were later exhibited. Car builders are now given the opportunity of acquiring these equipments. By experimentation, they can build-up what in their opinion is ideal lighting distribution. Plans are under way for a large general demonstration at which these lighting distributions will be exhibited and judged.

Through its Highways Committee, the Society has continued to participate in a third cooperative project, the motor-truck impact-tests made at the Bureau of Public Roads. The Rubber Association of America is the third party interested in the investigation. The objects to be accomplished were

(1) A determination of cushioning effect as influenced by the various tire, truck and road factors

(2) A determination of road stresses as influenced by motor-truck-wheel impact

The major part of the effort has been devoted to the first object. The tests originally scheduled have been completed, and the data are available in final form. An account of the work was given at the Tire Session of the Summer Meeting in a paper presented by J. A. Buchanan and J. W. Reid.

Included in the program for the future is the cutting down and testing of cushion and solid tires to represent worn conditions. Additional tests will be made with such recently designed tires as properly come within the scope of the investigation and have been placed in general service. Tests will be made with a high-speed motorcoach chassis, and the possibility of including in the tests a six-wheel truck equipped with solid tires has been suggested. Further research on instrumentation is also planned.

The Society's research on riding-qualities has been concerned mainly with a study of the value of the contact-type of accelerometer in measuring the shocks felt in motor vehicles. A report on some of this work was published in the Automotive Research columns of THE JOURNAL.[5] Further study will be made along these lines in the effort to find some method of measuring the riding-qualities of a motor car that will be generally acceptable.

[5] See THE JOURNAL, March, 1926, p. 248.

MEETINGS OF THE SOCIETY

(*Concluded from p. 569*)

possibility of reducing landing speed, increasing all round performance and improving lateral control. Machines equipped with such a device will challenge the achievements of the Autogyro.

The tailless airplane may achieve a definite success; at any rate, its many interesting principles are likely to be taken under serious consideration by designers in machines of more conventional type. Thus, the use of wings with constant center of pressure and neutral tail surfaces will be studied extensively. Ailerons of the neutral type were suggested by me in 1917, and no doubt by many others before and since. They are not likely to be studied more intensively. Increased longitudinal control can be relied upon more in the future than inherent longitudinal stability. Attempts may be renewed to achieve a constant center of pressure for biplanes by the use of decalage and stagger, with neutral tails and perhaps no stabilizers at all.

There may be combinations of these various principles, such as, for example, slotted airfoils and flaps in conjunction with wings of constant center of pressure and neutral elevators.

It is remarkable how aerodynamics seems to move in cycles; a cycle of stagnation and complacency and a conviction that nothing but refinement of standard types remains to be achieved is followed by a period of intellectual excitement and a rapid move forward.

I cannot resist the temptation of insisting on the value of individual effort in aerodynamics. None of these discoveries proceeded from "official" science.

Archibald Black Speaks

With especial reference to the organization, layout and equipment of airports, airways and flying-fields, Archibald Black, consulting engineer, presented an illustrated paper in which he traced the development of equipment and facilities both in this Country and abroad. Included in Mr. Black's paper were descriptions of various types of hangar construction and of equipment, such as means for illumination—beacons and landing lights—ground markings, catapults for launching airplanes, and mooring masts for handling lighter-than-air craft.

Wings of the Fleet

Lieut. H. S. Kendall, U. S. N., showed and explained a motion picture entitled Wings of the Fleet in which aeronautical activities of the Navy were vividly portrayed.

Under the chairmanship of Neil MacCoull, the session included important items of discussion that were contributed by E. R. Ross, W. Laurence LePage, Captain DePew, Mr. Barnard, H. Nutt, and others.

Vol. XVIII June, 1926 No. 6

Design, Production and Application of the Hypoid Rear-Axle Gear

By Arthur L. Stewart[1] and Ernest Wildhaber[2]

Semi-Annual Meeting Paper *Illustrated with* Photographs and Diagrams

ABSTRACT

After defining hypoid-gears and outlining their action, together with their general characteristics and advantages, the authors compare them specifically with spiral-bevel gears and follow this with a description of how the axis of the pinion is offset from the axis of the gear and how the direction of the offset determines whether the spiral is right-handed or left-handed.

Considering pitch-lines, details of the mesh between a crown-gear and an offset pinion are presented, since this constitutes a special case of hypoid-gearing, and the application of these principles to a pair consisting of a pinion and a tapered gear is discussed. The rate of endwise sliding, the proper ratio of gear-diameters, tooth loads and tooth profiles are other phases treated specifically, and computations of surface stresses by the Hertz formulas, with special reference first to a comparison between helical teeth and straight teeth, and then with reference to hypoid-gears, are outlined.

Following a description of the newest method for the production of hypoid-gears and a statement of the machining operations needed, it is pointed out that the finish-cutting of the pinion is the only major operation which requires machinery different from that used for the production of spiral-bevel gears and pinions.

HYPOID-GEARS are tapered gears having offset axes. In general they look like spiral-bevel gears which, in many cases, they will replace. The tooth action of hypoid-gears combines the rolling action of spiral-bevel gears with a percentage of endwise sliding. The chief advantages of hypoid-gears are noiseless operation, increased load-carrying capacity, the possibility of high reduction and low numbers of teeth, long life, and high efficiency. Hypoid-gears have always presented great difficulties, in both design and production. Up to the present, no gears of this type having mathematically correct forms of teeth adapted for successful commercial production have been known.

In a new development, the Gleason Works presents hypoid-gears having an accurate and practical tooth-shape and permitting production at no higher cost than that for spiral-bevel gears. The gears can be cut like spiral-bevel gears on the existing gear-generating machines, and the pinions are cut on other machines of the same general design, with added adjustment-features. Moreover, the newly developed method of cutting is much more flexible than has heretofore been attained. Even the transverse tooth-profiles can be modified at will to any extent. They can be curved so as to bear on their whole depth, while transmitting uniform motion, or they can be modified so as to bear only on part of their depth. These new hypoid-gears have been tested extensively in rear axles under very severe conditions and have carried overloads successfully while continuing to operate with an unusual degree of quietness.

[1] M.S.A.E.—Chief engineer, Gleason Works, Rochester, N. Y.
[2] Gleason Works, Rochester, N. Y.

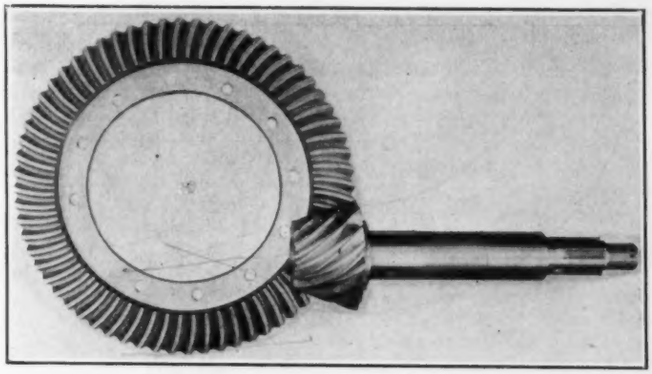


Fig. 1—A Pair of Hypoid-Gears
The Pinion Has 13 Teeth and the Gear Has 64. The Pinion Axis Is Offset from the Axis of the Gear

Hypoid-Gears

Fig. 1 illustrates a pair of hypoid-gears having 13 teeth in the pinion and 64 teeth in the gear. For comparison, Fig. 2 shows a pair of spiral-bevel gears having the same numbers of teeth and the same diameter, 12.8 in., of the gear. The most striking difference between the two pairs is the offset of the pinion axis from the axis of the gear, on the hypoid-pair. Another marked difference is the increased size of the hypoid-pinion as compared with the bevel-pinion, and it is noted also that the tooth inclination on the hypoid-gear, or its spiral angle, is small, while the spiral angle of the hypoid-pinion is as large or larger than the spiral angle of the bevel-pinion. These differences all have an influence on the performance and the characteristics of hypoid-gears as will be discussed later in the paper.

Names prominently connected with prior developments of hypoid-gears in the last decade are those of

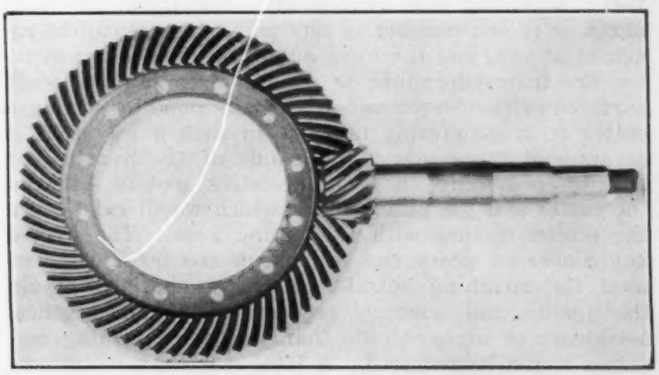


Fig. 2—A Pair of Spiral-Bevel Gears
This Pair Has the Same Numbers of Teeth and the Same Gear-Diameter as Those of the Hypoid-Gears Shown in Fig. 1. The Hypoid-Pinion Is Larger than the Bevel-Pinion. It Is Notable Also That the Spiral Angle of the Hypoid-Gear Is Small, but the Spiral Angle of the Hypoid-Pinion Is as Large or Larger than the Spiral Angle of the Bevel-Pinion

H. D. Williams, G. M. Bartlett, R. M. Uhlmann, Reginald Trautschold, and Nicola Trbojevich. The new developments made at the Gleason Works comprise new tooth-shapes for hypoid-gears as well as new methods of production and are covered by a series of pending patents. The tooth-shape is derived from surfaces of revolution and permits the use of the usual type of rotary cutters for generating the teeth.

Two types of tooth shape and two corresponding methods of production have been developed. The earlier method consists in forming the gears without generating roll is affected as if the pinion would roll and slide on a crown-gear whose axis is offset from the axis of the pinion.

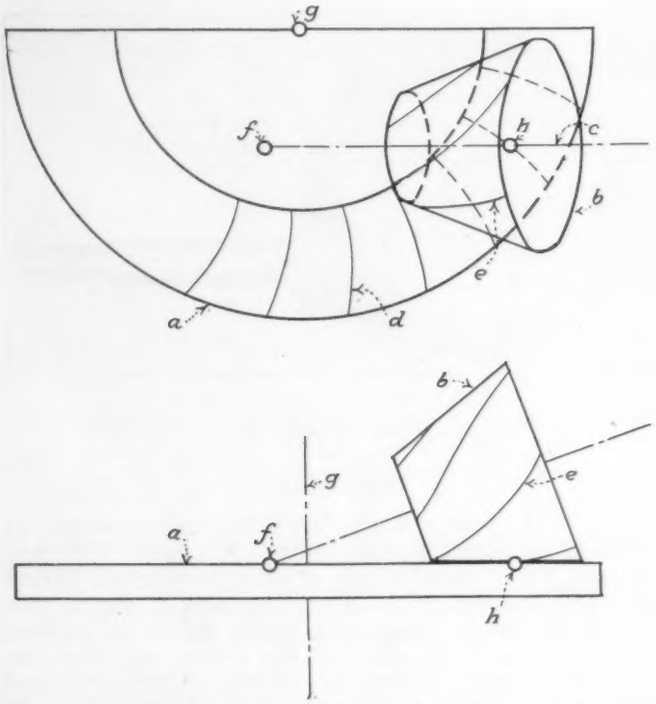


FIG. 3—MESH BETWEEN A CROWN-GEAR AND AN OFFSET PINION
Designating *a* as the Pitch-Plane of a Crown-Gear and *b* as a Conical Pitch-Surface of a Pinion, the Two Pitch-Surfaces Make Contact in a Line, *c*, Called the Line of Action; *d* and *e* Are Mating Pitch-Lines That Make Contact with Each Other in Changing Points on the Line *c*. The Action along the Line *c* Is Not Changed, Whether the Conical Surface *b* Is Considered or Whether the Action of the Pitch-Lines Is Analyzed in the Development of the Conical Surface to the Plane *a* of the Crown-Gear. The Developed Pinion-Surface Then Rotates about the Apex *f* of the Pinion, While the Crown-Gear Continues To Turn on Its Axis *g*

tion. A tooth space of the gear is then the exact complement or counterpart of the cutting surface of the tool. According to a general law of gearing, the tooth surfaces of one member of any pair of gears can be assumed at will, and the tooth surfaces of the other member are then determined or generated to suit the tooth surfaces of the first member. This is done by setting a cutter on a generating machine in such a way that it covers and represents a tooth side of the hypoid-gear and by providing the same relative motion between the cutter and the pinion blank which would exist when the pinion meshes with its mating gear. The hypoid non-generated gears can be cut on the machines now used for roughing spiral-bevel gears; but, to obtain the quality and accuracy required for finished gears, machinery of higher grade than the gear-roughing machines would be required. A later method permits cutting the gears on the known standard gear-generating machines exactly like spiral-bevel gears. The pinions are cut in either case on a machine that differs from the standard gear-generating machinery by permitting additional adjustments. In the latter case, the generat-

THE OFFSET

The axis of the pinion is offset from the axis of the gear by a distance that varies with the diameter and with the ratio. Standard offsets of 1½, 2, 2½, 3 and 3½ in. are in use. The direction of offset determines the "hand" of the spiral. In rear-axle design, a pinion below center will have a left-hand spiral and, a pinion above center will have a right-hand spiral. The position below center is preferable for two reasons; first, the axial thrust resulting on the pinion on forward drive is directed away from the gear, and heavy loads tend to move the pinion out of mesh rather than draw it in; second, the contact between mating tooth-surfaces is more intimate on the drive side. This quality will be explained further in a later section. It is more pronounced on ratios such as used on passenger cars than on the larger ratios used on trucks.

Objection to the above-center position of the pinion, so far as end-thrust is concerned, can be eliminated by making the bearing and the housing arrangements sufficiently rigid to prevent the pinion from wedging into the gear. The offset of the axes is the cause of a certain amount of endwise sliding in the teeth. The teeth of hypoid-gears should, therefore, extend lengthwise along such lines as to permit this sliding. Therefore, pitch-lines of hypoid-gears are subject to restrictions that do not exist on bevel-gears.

PITCH-LINES

As an illustration, we will consider the mesh between a crown-gear and an offset pinion, which is a special case of hypoid-gearing. Referring to Fig. 3, *a* and *b* are what might be called a pitch-plane of a crown-gear and a conical pitch-surface of a pinion. The two pitch-surfaces make contact in a line, *c*, while *d* and *e* are mating pitch-lines that make contact with each other in changing points of line *c*, the contact-line between the two pitch-surfaces which can be called the line of action. Evidently, the action along line *c* is not changed, whether the conical surface *b* is considered or whether the action of the pitch-lines is analyzed in the development of the conical surface to the plane *a* of the crown-gear. The developed pinion-surface then rotates about the apex *f* of the pinion, while the crown-gear continues to turn on its axis *g*. This method of analysis is convenient because it reduces the problem of conjugate pitch-lines to the known problem of conjugate tooth-profiles. Fig. 4 indicates the crown-gear and the developed pinion-surface. Considering an average point *h* on the line of action *c*, the normal line *i* at this point with respect to two contacting pitch-lines *d* and *e* should pass through the point *j*. This point is what would be called the pitch-point in ordinary gearing; namely, the contact-point between two circles, *k* and *l*, which roll upon each other without sliding when the two bodies are turned at a constant ratio.

If the ratio between the crown-gear and the developed pinion-surface is assumed, the point *j* is determined readily and the normal *i* is the connecting line *h-j*. Conversely, the normal *i* at the point *h* can be assumed and the pitch-point *j* determined as the intersection point between the normal *i* and the line *m* that connects the centers *f* and *g*. The point *n* is another point of mesh on the line of action. The normal *o* to the contacting pitch-lines at *n* necessarily must pass again through the point *j* inasmuch as, in gears running on parallel axes *f* and *g*, the profile-normal at any point of contact along the line of

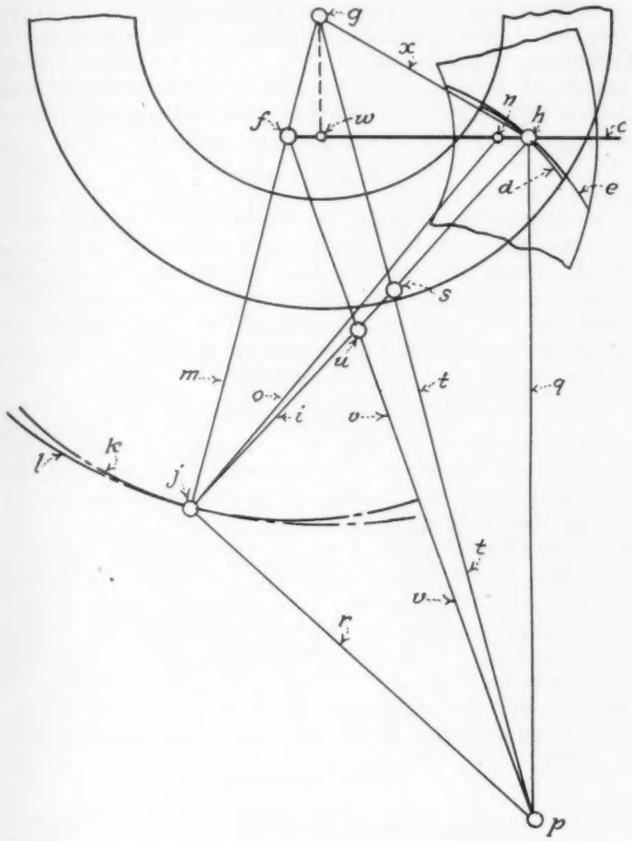


FIG. 4—CROWN-GEAR AND DEVELOPED PINION-SURFACE

Considering an Average Point, h, on the Line of Action c, the Normal Line i at This Point with Respect to Two Contacting Pitch-Lines d and e Should Pass through the Point j. This Point Would Be Called the Pitch-Point in Ordinary Gearing, Being the Contact-Point between Two Circles k and l That Roll upon Each Other without Sliding When the Two Bodies Are Turned at a Constant Ratio

action c always passes through the pitch-point. The motion of a normal itself from i to o can, therefore, be considered as a motion in which one end-point of this normal moves along the line c, and where the normal may slide along its own direction through a fixed point j. The instantaneous motion of the normal i can be considered as an infinitesimal rotation about an instantaneous center, p. The latter naturally must be on a line, q, that is perpendicular to the motion at the point h of the normal under consideration; that is, perpendicular to the line c. Moreover, it must be on a line, r, which is perpendicular to the motion of the normal at j, in its own direction. The point p is, therefore, determined as the intersection point of a normal at h to the line of action c and of a normal at j to the line i itself.

The center of curvature s of the pitch-lines naturally moves about the center g. Inasmuch as it also can be considered moving about the instantaneous center p, it can be situated only in the connecting line t of the instantaneous center p and the center g of the crown-gear; otherwise, the direction of motion about the center g and the direction of motion about the center p could not coincide, since one motion would exclude the other.

The same considerations can be applied to the developed pitch-surface of the pinion. The center of curvature u of the pitch-line of the pinion is determined by connecting the instantaneous center p with the apex f of the pinion by a line, v. The intersection point u of this line with the normal i is the center of curvature in the pinion.

Conversely, the apex f of the pinion could be determined, for instance, from the known radius of curvature of the pitch-lines d; that is, from the known location of the center s. To this end, the line q and the line t are drawn. Then, the intersection point p is projected to the normal i as the pitch-point j. Apex f is found by drawing the line m.

If the pinion apex is located on a perpendicular through g to the line of action c, that is, at w, so that the line g-w is perpendicular to c, the above case coincides with that previously treated by Nicola Trbojevich in analyzing the mesh between the pitch-lines of a hob thread and the pitch-lines of a crown-gear, according to his invention of hobbing bevel-gears.

Having thus determined the interrelation between mating pitch-lines of a pinion and of a crown-gear, the next step is to apply this knowledge to a pair consisting of a pinion and a tapered gear. If the gear is non-generated and the pinion is generated to match the gear, the same relations between mating pitch-lines can be used as determined previously for a pinion and an offset crown-gear. The crown-gear is then considered the development of the gear. In Fig. 4, the point g is the apex of the gear as well as the center of the crown-gear, and the line x is the projected axis of the gear. No error whatever is introduced thereby. If, however, both gear and pinion are generated, it is necessary to determine the pitch-lines more accurately, as will be shown later.

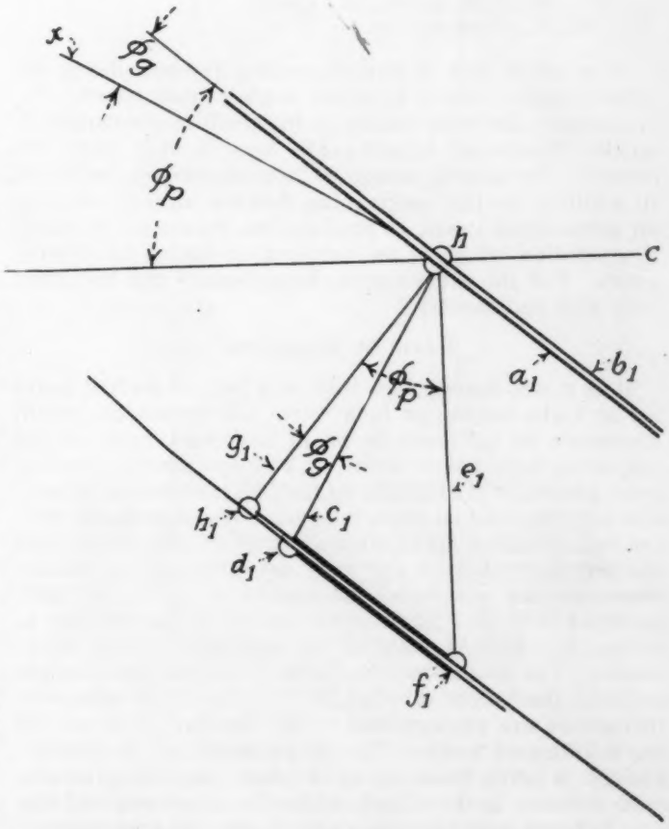


FIG. 5—LENGTHWISE SLIDING AT POINT h

The Area Around the Point h of Fig. 4 Is Shown in Greatly Enlarged Scale, a_1 and b_1 Being the Contacting Tangents at the Point h. During a Small Motion of the Gear and Pinion, the Pitch-Line of the Gear, Shown as a Straight Line in This Drawing, Moves in the Direction of c_1 of the Gear Periphery; That Is, in a Direction Perpendicular to the Line x. Point h of the Gear Then Assumes a Position, d_1. The Pitch-Line of the Pinion Moves in the Direction of the Periphery of the Pinion; That Is, in Direction e_1, Perpendicular to c. Point h of the Pinion Has Then Arrived at a New Position, f_1. Evidently the Distance of the Points d_1 and f_1 from One Another Is the Amount of Lengthwise Sliding

Rate of Lengthwise Sliding

We will now consider lengthwise sliding at the point h. Fig. 5 shows in a greatly enlarged scale the area of Fig. 4 around point h; while a_1 and b_1 of Fig. 5 are the contacting tangents at the point h. During a small motion of the gear and pinion, the pitch-line of the gear, shown as a straight line in this scale, moves in the direction c_1 of the gear periphery; that is, in a direction perpendicular to the line x. The point h of the gear then assumes a position d_1. The pitch-line of the pinion moves in the direction of the periphery of the pinion; that is, in the direction e_1 perpendicular to c. The point h of the pinion has then arrived at a new position, f_1. Evidently, the distance of the points d_1 and f_1 from one another is the amount of lengthwise sliding.

The rate of sliding can be expressed in percentage of the peripheral motion. However, this will result in two different values for gear and pinion, inasmuch as corresponding peripheral motions c_1 and e_1 are different. Therefore, it is preferable to express the rate of sliding as a percentage of normal motion g_1; that is, of the displacement of the tangents a_1 and b_1 in a normal direction.

Let φ_p and φ_g be the spiral angles of pinion and gear, as indicated in Fig. 5. Moreover, M_s equals sliding and M_n equals normal motion. In Fig. 5, M_s equals the distance d_1–f_1 and M_n equals distance h–h_1.

$$M_s = \text{distance } f_1 - h_1 \text{ minus distance } d_1 - h_1$$
$$M_s = M_n \tan \phi_p - M_n \tan \phi_g$$
$$M_c/M_n = \tan \phi_p - \tan \phi_g$$

It is noted that in hypoid-gearing the peripheral motions c_1 and e_1 are at an acute angle to each other. For this reason, endwise sliding in the teeth is comparatively small. Moreover, hypoid-gears have a very high efficiency. The sliding action of hypoid-gears is sufficient, in addition to the overlapping feature already existing on spiral-bevel gears, to produce the degree of quietness in operation which is an outstanding factor on hypoid-gears. For the same reason, hypoid-gears can be lapped very well and rapidly.

Ratio of Diameters

It is a well-known fact that in a pair of helical gears set at right angles, or in a worm and wheel, the pitch-diameters do not have to be in the exact ratio of the respective numbers of teeth. In consequence, the circular pitch generally is different on the two members of a pair, and only the normal pitch is equal. The same holds true for hypoid-gears. The circular pitch of the pinion and the circular pitch of the gear are proportional to the corresponding peripheral movements e_1 and c_1, as indicated in Fig. 5. Their ratio evidently equals cos φ_g cos φ_p, the inverse ratio of the cosines of their spiral angles. The hypoid-member with the larger spiral-angle contains the larger circular pitch. The pitch-diameters themselves are proportional to the circular pitch and to the number of teeth. The spiral angle φ_p of hypoid-pinions is being made 35 or 40 deg., depending on the tooth number in the pinion, while the spiral angle of the gear is being kept between 5 and 15 deg. In consequence, the average pitch-diameter of a hypoid-pinion is increased over the average pitch-diameter of a corresponding bevel-pinion by from 20 to 30 per cent, the gear diameter being the same. Naturally, this increases the strength of the hypoid-pinion. Moreover, it is possible to effect large ratios with hypoid-gears that are difficult to obtain with the spiral-bevel gears, on account of prohibitively small pinion-diameters.

A larger percentage of diameter increase than that mentioned previously can be obtained by increasing the spiral angle of the pinion. At a 10-to-1 ratio, a hypoid-pinion of 1¾-in. pitch-diameter can be made to mesh with a gear of 10-in. pitch-diameter, but a corresponding bevel-pinion would have a pitch-diameter of only 1 in.

Tooth Loads

In computing the tooth loads of a pair of hypoid-gears, the circumferential or tangential tooth-load P of the gear at the center of the face can be determined from the known torque, and the pressure or load normal to the tooth surface is then determined by dividing by the cosine of the normal pressure-angle ψ and by the cosine of the spiral angle φ_g of the gear; that is

$$P_n = P/(\cos \psi \times \cos \phi_g) \qquad (1)$$

The amount Pn is the total tooth-load or, in other words, the resultant of all components. It is noted that this total tooth-load is only slightly larger than the effective circumferential or tangential tooth-load P of the gear, for if we introduce as average amounts $\psi = 17\frac{1}{2}$ deg. and $\varphi_g = 8$ deg., we obtain $P_n = 1.06\ P$; that is an increase of 6 per cent.

In spiral-bevel gears, the total tooth-load P_n is considerably larger than the effective tangential tooth-load. If a pressure angle of $17\frac{1}{2}$ deg. and a spiral angle of 35 deg. are assumed, the total tooth-load is $P_n = 1.28\ P$; that is, an increase of 28 per cent as compared with 6 per cent.

Tooth Profiles

The analysis of the tooth profiles of hypoid-pairs is somewhat tedious and cannot be carried out in a single plane. All hypoid-pinions have the feature in common that the tooth profile of one side is more curved than the tooth profile of a corresponding bevel-pinion and that the tooth profile of the other side is less curved or flatter than the profile of a corresponding bevel-pinion.

Taking the average of opposite tooth-profiles it can be stated that, on hypoid gear-pairs in general, the tooth profiles are similar to those of spiral-bevel gears. Opposite tooth-profiles of hypoid-pinions are, however, differently curved. The concave tooth-side of a hypoid-pinion contains a flatter profile than the convex tooth-side. Partly on account of this difference in curvature, the different pressure-angles of $17\frac{1}{2}$ and 20 deg. are being used on the drive and on the reverse sides respectively; that is, on the concave and the convex sides of the pinion teeth.

Comparison of Surface Stresses

The surface of stresses of contacting teeth, that is, the stresses of the tooth surfaces along the lines of contact in the moment of contact, are very important quantities inasmuch as they are the decisive factor concerning the life and the wear of the gears. As is well known at present, the wear of properly lubricated surfaces is practically zero at various rates of sliding so long as the surface stresses are kept below a certain limit that depends on the material used. Surface stresses can be computed with the Hertz formulas, which are widely used in computing the stresses in ball and in roller-bearings.

We will first compare helical and straight teeth. When calculating the surface stresses in helical and in straight spur-gears with the Hertz formulas and considering the total length of the line of contact on the various teeth in simultaneous contact, it is found that helical and straight teeth are practically equivalent with respect to surface

capacity; for, although the tooth contact is more intimate in helical gears, the depth of the helical teeth is smaller, being in a constant proportion to the normal pitch, and the normal or total tooth-load is larger on helical teeth for the same torque transmitted. The result can be applied directly to spiral and straight-tooth bevel-gears.

Considering hypoid-gears, the intimacy of tooth contact is substantially the same as in spiral-bevel gears, when taking the average of opposite tooth-sides of hypoid-gears; but, comparing pairs of equal diameter of the gears, the total tooth-load on hypoid-gears is considerably smaller than that on spiral-bevel gears. Moreover, the tooth height, being at a constant proportion to the normal pitch, is larger. These two factors constitute the reason that hypoid-gears are able to carry a considerably larger load under equal surface-stresses, as compared with spiral or straight-tooth bevel-gears.

The calculated loads are in the proportion of $(\cos \varphi_o \cos \varphi_p)^2$. This proportion is given below for three cases; namely, for spiral angles φ_p at the pinion of 35, 40 and 45 deg. and corresponding spiral-angles φ_o at the gear of 5, 10 and 15 deg. The proportion is 1.48, 1.66 and 1.87 in the three cases. Hypoid-gears have, theoretically, a surface capacity increased by 48, 66 and 87 per cent over the surface capacity of spiral or straight-tooth bevel-gears, at equal diameters of the gear. These figures refer to the average surface-capacity of opposite tooth-sides. The surface capacity of either side is somewhat different. Usually, the drive side contains the larger surface capacity; that is, a capacity still larger than that given above.

Production of Hypoid-Gears

The two methods of production developed by our company have already been mentioned. The earlier method, in which the gear is cut without generating roll, is theoretically accurate; that is, it does not contain the least theoretical error or approximation. This method has now been discontinued in favor of a new one that gives just as good or better results on account of its increased flexibility, which incidentally permits the use of the present gear-generating machines on the gears. We will limit our explanations to this method. It will be seen that the method has been worked-out mathematically to a high degree of perfection and is not based on any assumption, of which the effect is not entirely known. Although somewhat long in calculation, this method is a very practical one in operation and permits refinements not previously available.

According to this newer method, the gear is cut exactly like a spiral-bevel gear of the same pitch-angle. In the production of the pinion a gear-generating machine of our own construction with additional adjustments is used, and the pinion axis is offset from the axis of the cradle. The cutter is of our usual type and has straight cutting-edges that are at an angle to the axis of the cutter. Preferably, different cutters are used on gear and pinion. One gear-cutter and one pinion-cutter can cover all cases. It is not necessary to use cutters with varying amounts of pressure-angle correction as has been the practice with spiral-bevel gears. During the generation, the cutter represents a crown-gear with an offset axis and conjugate to the same pinion that is also conjugate to its known mating gear. A generating motion is provided between the cutter and the pinion blank as if the pinion would roll on the crown-gear.

An analysis of the mesh between a hypoid-pinion and its mating gear is as follows. In Figs. 3 and 4, the mesh between a pinion and a crown-gear has been illustrated. It has been found that if the teeth extend along certain pitch-lines, either side of the teeth meshes along the same line of action in the pitch-plane of the crown-gear; that this line of action c, Fig. 4, is independent of the pressure angles; and that the projected tooth-normals i and o of either tooth-side intersect at the same point j.

Somewhat analogous conditions can be determined in the present case, in which the mesh in a pitch-plane between two hypoid-gears is considered, the axes of which are both inclined to said pitch-plane. In Fig. 6, i_1 and j_1 are pitch-surfaces of gear and pinion that are tangent to a common plane selected as the drawing plane of Fig. 6 and k_1 and l_1 are the projected axes of gear and pinion, also being the contact-lines between the pitch-plane and the pitch surfaces i_1 and j_1. However, in contradistinction to the former case of pinion and crown-gear, the line of action of the same character cannot extend along the line l_1, but extends along a line, m_1, which is inclined at a small angle, Θ, to the line l_1. The relation between the location of the points j and s can be determined in a

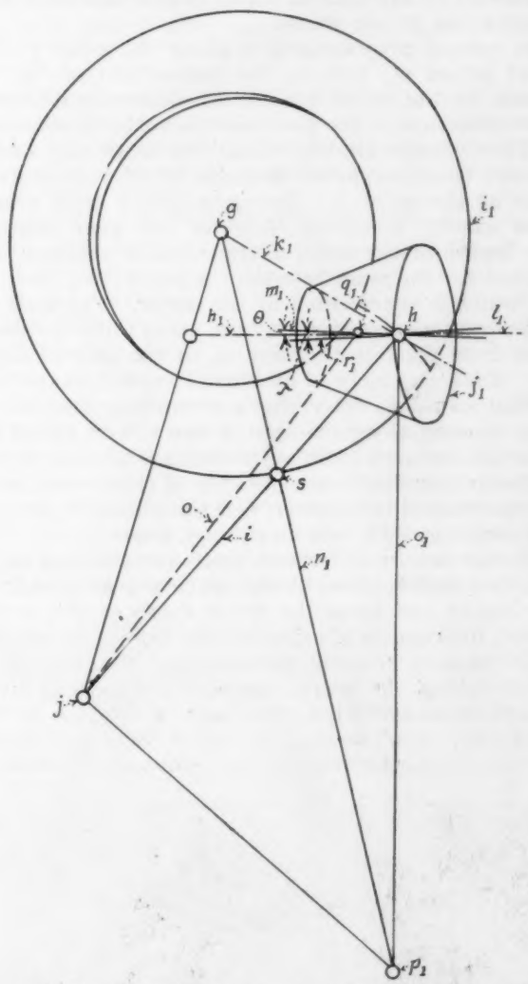


Fig. 6—Mesh When Both Axes Are Inclined to the Pitch-Plane

Considering the Mesh in a Pitch-Plane between Two Hypoid-Gears When the Axes Are Both Inclined to the Pitch-Plane, i_1 and j_1 Are Pitch-Surfaces of Gear and Pinion That Are Tangent to a Common Plane Selected as the Drawing Plane of This Illustration, and k_1 and l_1 Are the Projected Axes of Gear and Pinion, Also Being the Contact-Lines between the Pitch-Plane and the Pitch-Surfaces i_1 and j_1. In Contrast to the Case of the Pinion and Crown-Gear, the Line of Action of the Same Character Cannot Extend along the Line l_1 but Extends along the Line m_1, Which Is Inclined At a Small Angle, Θ, to the Line l_1

manner analogous to the one explained with reference to Fig. 4; that is, the point j can be determined by drawing the line n_1, connecting the points g and s and the line o_1 through the point h at right angles to the line of action m_1. The intersection-point p_1 is then projected to the normal i, thus locating the point j. Instead of using a graphical solution as illustrated by the diagram, the location of this point and of all other points can also be determined by calculation, which is more accurate and in exclusive use at our works.

The normal pressure-angles along the point q_1 of the line of action m_1, that is, the inclinations of the tooth normals at the point q_1, can be determined from the known structure of the gear and the cutter that produces it. They change slightly along the tooth and are also different from the pressure angle of the pinion-cutters except at the point h. To cut a pinion with pressure angles exactly matching those of the gear along the whole length of the teeth, another line of action r_1 is determined for the mesh between the pinion and its crown-gear, which is represented by the cutter. The mesh during generation extends, therefore, along the line r_1, which differs from the line of action m_1 of the pair of hypoid-gears. Line r_1 is inclined by a small angle, λ to the line l_1. The final step is to determine a crown-gear that actually is able to mesh along the figured line r_1 with the pinion; and which contains tooth sides that are conical surfaces of suitable diameter. A tooth side of this crown-gear is then represented by a cutter, and the pinion is generated while meshing with said imaginary gear.

With the developed method, tooth surfaces can be produced that match those of the mating gear along their whole length and along the whole depth of the profiles; however, for reasons of adjustability, that is, to provide a certain range of running positions and to allow for non-rigid mounting, the bearing area of the teeth is preferably somewhat restricted, especially in the case of rear-axle drives. Any desired deviation from full bearing can be obtained lengthwise of the teeth and on the depth;

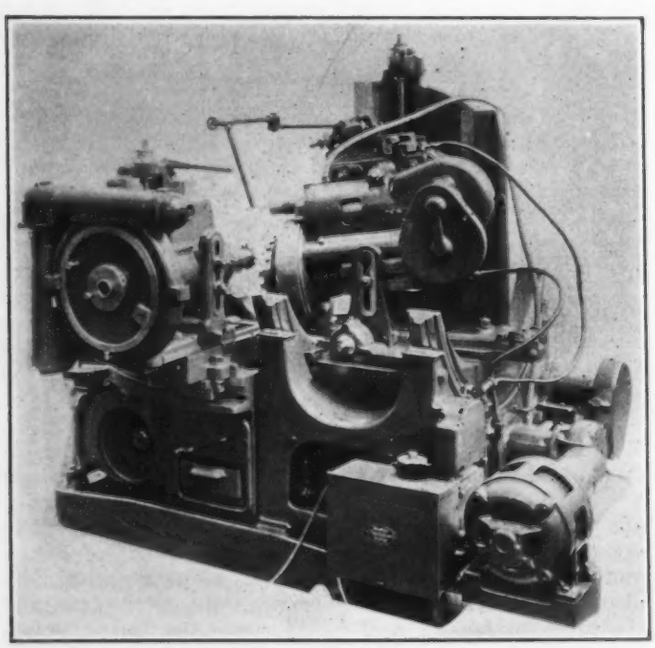


FIG. 7—PINION FINISH-CUTTING MACHINE
This Machine Has Additional Adjustments for Setting Purposes. The Added Settings Are a Vertical Adjustment of the Work-Spindle in Accordance with the Offset of the Pinion with Respect to the Gear and Two Angular Adjustments of the Cutter-Spindle about Horizontal and Vertical Axes

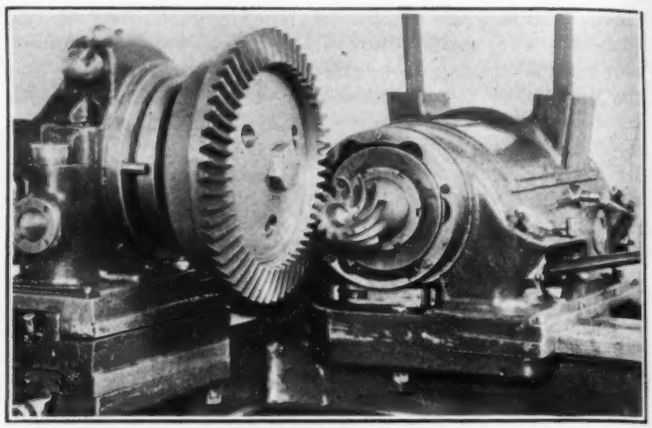


FIG. 8—TESTING MACHINE
Method Employed in Testing a Pair of Hypoid-Gears Is Shown. In the Testing and the Lapping Operations, the Machines Must Have the Same Offset of Work-Spindles as the Pinion and the Gear Shafts Are To Have in the Final Assembly

that is, on the profile. More curved or less curved tooth-profiles on the pinion are obtained by changing the offset between pinion and crown-gear after recalculating the settings. It has been pointed out previously that, on the tooth side of the pinion, which, during the meshing, is opposite the axis of the gear, an increased offset requires a flatter profile; that is, less curvature of the profile. If, therefore, on this side, which is usually the drive side, the offset is increased during the generation, the resulting profile will be flatter; and, if the offset is reduced, the resulting profile will be more curved. The opposite holds true for the tooth side of the pinion, which is on the side of the axis of the gear or crown-gear.

Bias bearing, that is, a tooth bearing extending obliquely across the tooth surface and which has occurred and been found objectionable in certain cases of curved-tooth gearing, results when the pressure angles of gear and pinion do not match along the whole length of the teeth. The pressure angles of hypoid-gears are made to match along the whole length of the teeth and bias bearing is thus entirely eliminated.

Another feature illustrating the flexibility of the method of cutting is the fact that the tooth bearing of a pair of hypoid-gears under production can be raised or lowered or moved endwise simply by changing the cutter setting. If it is desirable, for instance, to counteract hardening changes, to shift the tooth bearing, the tooth bearing can be placed readily on any desirable spot whatever on the tooth surface.

MACHINING OPERATIONS

Production operations are, in general, the same for hypoid-gears as for spiral-bevel gears. This includes preparing the blanks; cutting the teeth; hardening; grinding bores, shanks, and the like; and lapping the teeth. The blanks are turned to different dimensions, being larger in the case of the pinion and of slightly different face and back angle and outside diameter in the case of the gear. Machines for rough-cutting the gear and pinion and for finish-cutting the gear are the same as used for spiral-bevel gear. The pinion finish-cutting machine has additional adjustments for setting purposes, after which the cutting operation itself is the same. The added settings are a vertical adjustment of the work-

(*Concluded on p. 600*)

General Results of the Cooperative Motor-Truck Impact-Tests

By JAMES A. BUCHANAN[1] AND J. W. REID[2]

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS, CHARTS AND DRAWINGS

ABSTRACT

SUFFICIENTLY accurate data having been obtained in 1924 to warrant proceeding with the extensive program of cooperative motor-truck impact-tests mapped out, authorized and instituted the preceding year, the tests have since been completed and the data therefrom made available in standardized final form under the direction of a joint committee representing the Bureau of Public Roads, the Rubber Association of America and the Society. The primary objects of the investigation were the determination of cushioning effect as influenced by the various tire, truck and road factors and the determination of road stresses as influenced by motor-truck-wheel impact, but it is the first of these objectives on which the major effort has been expended to date and to which the paper is confined.

After several cautionary explanations of the exact meanings and limitations of terms and procedure, the authors state eight preliminary deductions drawn from present available data before proceeding with their discussion of the mode of static and of impact-test accomplishment, and give a subsequent description of the accelerometer used, supplemented by details of accelerometer calibration and verification. An outline of the equipment utilized and of the actual road-conditions is presented and the artificial obstructions employed for producing impact force are specified.

The illustrated analysis given of the data obtained includes details of the highway and of the obstruction tests; a statement is made of the effects produced by the different types of tire equipment and those due to the kinds of truck, their size and the number of wheels with which they are equipped, and a series of miscellaneous observations having to do with unsprung-weight, tire compounding, front-wheel equipment, load distribution, speed, duration of impact, and the like is appended. In conclusion, an outline of proposed future work along these lines is stated.

THE motor-truck impact-testing project now being conducted by the United States Bureau of Public Roads at the experimental station near Arlington, Va., is in cooperation with the Society of Automotive Engineers and with the Rubber Association of America, being under the direction of a joint committee representing these organizations. The tests were authorized and instituted in 1923. However, due to the necessity for developing an accelerometer adapted to the conditions of these tests, it was not until the summer of 1924 that sufficiently accurate data were obtained to warrant proceeding with the extensive program laid out. The tests as originally scheduled have been completed and the data therefrom are available in standardized final form. The results have also indicated the need for further research in tire height as well as motor-truck and motorcoach design and equipment.

The primary objects of this investigation are the determination of (*a*) cushioning effect as influenced by the various tire, truck and road factors and road stresses as influenced by motor-truck-wheel impact. It is the first of these objects (*a*) on which the major effort has been expended to date and to which this paper is confined.

CAUTIONARY EXPLANATIONS

The term "cushioning effect," as used herein, deals with the vertical reaction between road and wheel only, and it is not to be confused with the popular term "riding-quality" although necessarily somewhat akin to it. Further, it should be remembered that this research has been concerned with but one phase of certain economic problems, the consideration of which should give due weight to the various other highway-transportation factors that are relevant to the subjects involved. It should be noted also that the results of the tests herein reported were obtained with equipment specified by the cooperative committee. The tires used were standard at the time of testing, and the results do not apply necessarily to tires that have been redesigned during or sub-

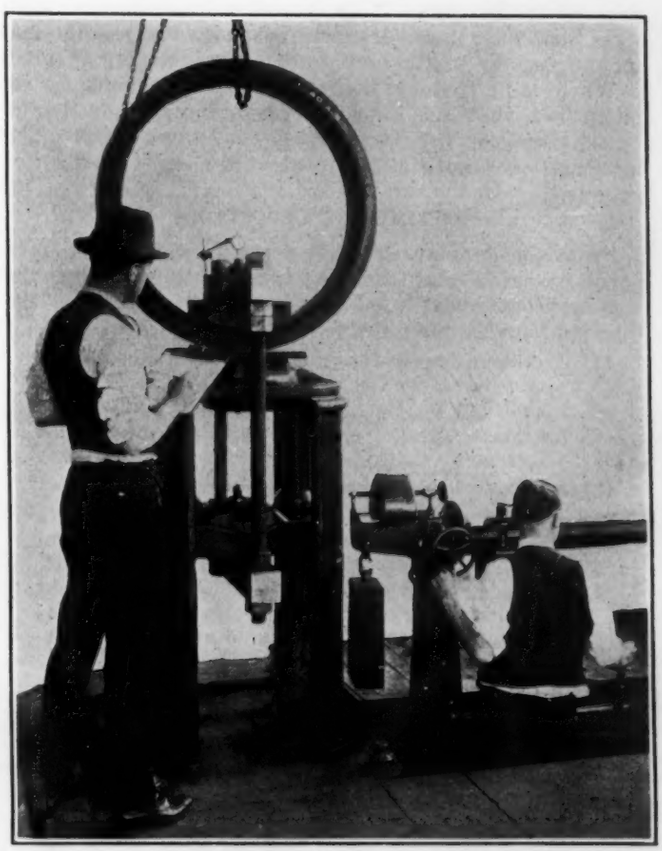


FIG. 1—METHOD OF MOUNTING A TIRE FOR THE STATIC TEST
The Tires Were Placed in a Testing Machine and Vertical Deflections Were Recorded As the Load Was Slowly Applied. From These Data, Load Versus Deformation Curves Were Drawn

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[2] Rubber Association of America, New York City.

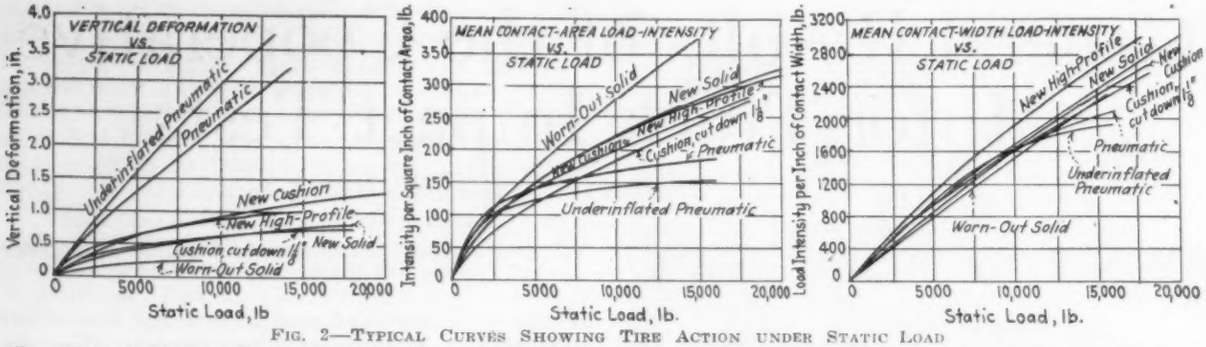


FIG. 2—TYPICAL CURVES SHOWING TIRE ACTION UNDER STATIC LOAD
The Effect of Load on Vertical Deformation, the Mean Contact-Area Load-Intensity and the Mean Contact-Width Load-Intensity Is Illustrated

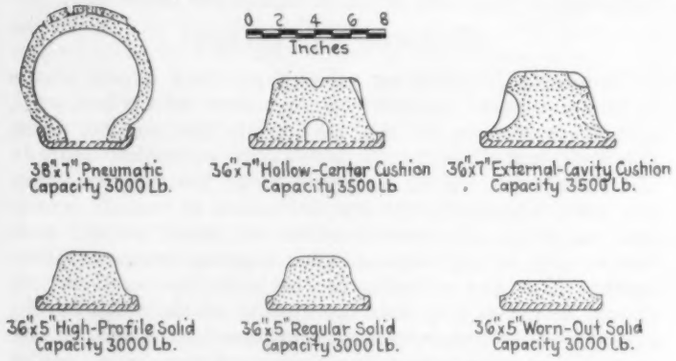


FIG. 3—TYPICAL TIRE CROSS-SECTIONS
The Form, Size and Capacity of the Pneumatic, the Cushion and the Solid Tires Employed for Testing Are Given

sequent to the tests. This is particularly the case with tires that have been designed specially for use in dual mountings, the profile heights being appreciably affected.

When using the data contained herein, it should be remembered that an impact force, expressed in pound units, does not necessarily have the same effect upon materials as does a static force of the same number of pounds.

PRELIMINARY DEDUCTIONS

From the data available at present, and it should be borne in mind that the data were obtained from the standard equipment used at the time of the tests, the following preliminary deductions can be drawn:

(1) Maximum impact-forces obtained with motor-truck tires in service can be measured with an accuracy sufficient for the needs of this investigation

(2) As static load increases, road-impact reaction increases

(3) As static load increases, the ratio of road-impact reaction divided by static load decreases

(4) Thickness and narrowness of tread rubber are desirable in reducing road-impact reaction

(5) Increasing the thickness of profile height of rubber has a very marked effect in reducing road-impact reaction in both single and dual mountings

(6) In the tire equipments, all of which were standard at the time of the tests, dual mounting causes heavier impact-forces than the corresponding single-mounting of the same total load-carrying capacity. This was determined on a pneumatic-tired 2-ton truck and on a solid-tired 5-ton truck

(7) Appreciable variation of cross-sectional rubber, or breaks in its continuity, cause heavy repeated impacts on the road

(8) Dual-mounted tires always should be mounted with the tread designs staggered

STATIC AND IMPACT-TEST PROCEDURE

The tests of tire-cushioning qualities are divided into two general groups; the static tests and measurements

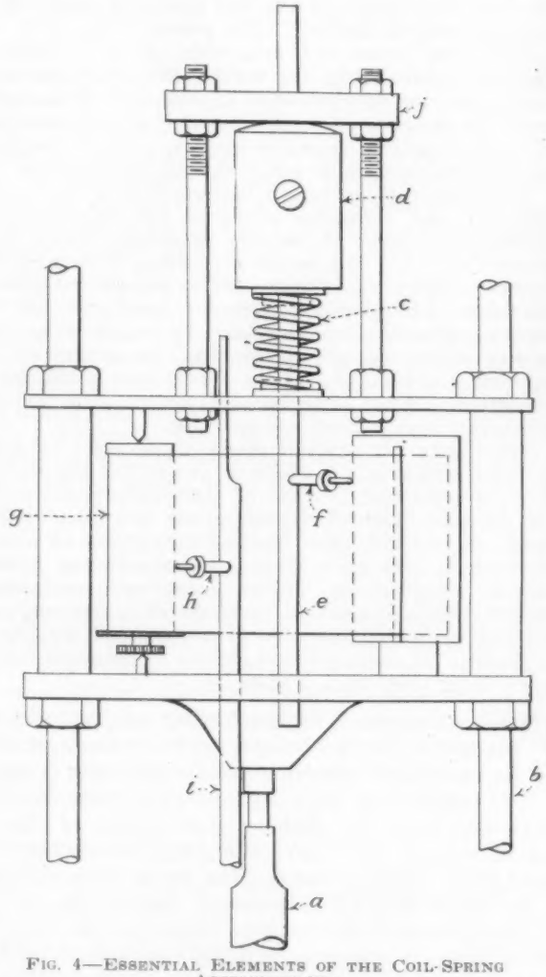


FIG. 4—ESSENTIAL ELEMENTS OF THE COIL-SPRING ACCELEROMETER
The Instrument Is Mounted To Follow Rigidly the Vertical Movement of the Right Rear-Wheel of a Motor Truck by a Tight, Self-Aligning Bearing, *a*, and the Device Slides on Guides *b* on the Truck Body. The Sensitive Element Is Composed of a Calibrated Coil-Spring, *c*, Supporting a Weight, *d*, of Known Mass. A Rod, *e*, Is Fastened to This Weight and Acts as a Guide and as a Stylus Holder. The Stylus *f* Records the Relative Movement of the Weight on Sensitized Paper Rolled on a Drum, *g*, That Is Driven by the Truck Wheel; Therefore, the Paper and the Truck Speeds Are Proportional. A Similar Record Is Made by the Stylus *h* Which Is Mounted on the Rod *i* That Is Actuated by the Rack and Pinion Located at the Truck Spring. A Back-Stop, *j*, Is Arranged above the Accelerometer Weight To Prevent Its Upward Movement beyond the Position at Rest, and No Initial Compression Is on the Spring Other Than That Due to the Weight Itself

and the impact tests. It is expected that, in most cases, a general relation will be found between these two test-methods which will shorten and standardize future tests.

In the static tests, the tires were placed in a testing machine and vertical deflections were recorded as the load was slowly applied. From these data, load versus deformation curves were drawn. The areas of tire contact were also taken at three loads on each tire, and reproductions were made of the impressions. From this the area, width and length of contact were obtained at the three loads. The hardness of the tread rubber was measured by a Shore Durometer. In addition, the weights, dimensions and trade names of the tires were recorded.

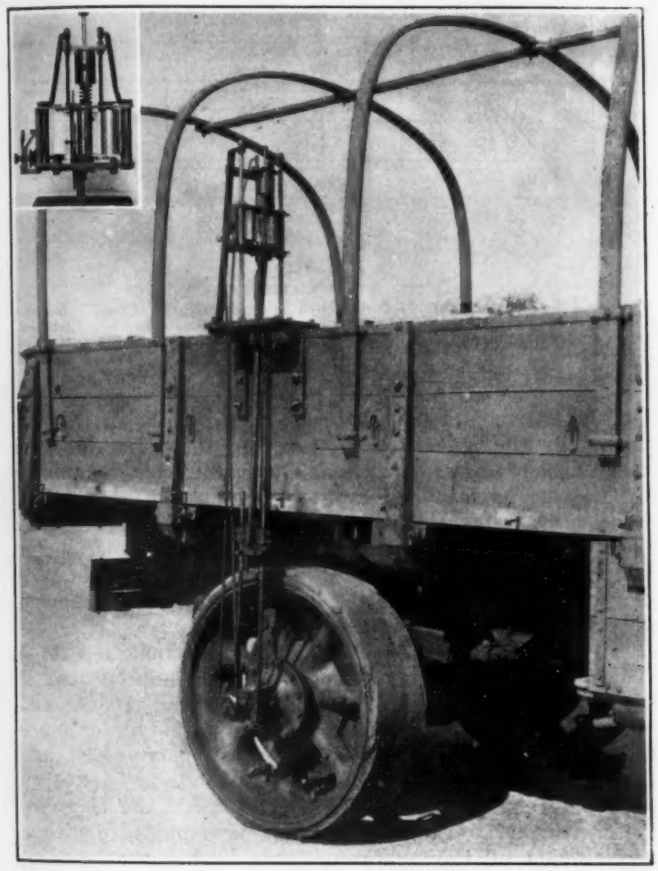


FIG. 5—ACCELEROMETER INSTALLATION
The Complete Apparatus as Mounted on a Test-Truck Is Shown, the Insert Being a Close-Up View of the Instrument Proper

Fig. 1 shows the method of mounting tires in the testing machine. Typical curves showing tire action under static loads are presented in Fig. 2, which illustrates the effect of load on vertical deformation, mean contact-area versus load-intensity, and mean contact-width versus load-intensity. In Fig. 3, typical tire cross-sections are depicted.

In the impact tests, the total vertical road-reaction is determined by a specially constructed measuring-apparatus known as an accelerometer, which is mounted on the test-trucks. This accelerometer was designed to measure the maximum vertical-accelerations of the truck wheel and to record simultaneously the proportional deflections of the corresponding truck-spring. The forces are computed by formula, and can be resolved into sprung and unsprung-components. The sprung-component is determined by measuring the change of truck-spring deflection from its static position at a given load to its position at the instant of impact. By referring to the proper portion of a previously prepared calibration-curve for the truck spring, the change in spring pressure from that at static load is obtained. The unsprung-component is determined by measuring the acceleration or the deceleration of the truck wheel, knowing the mass of the

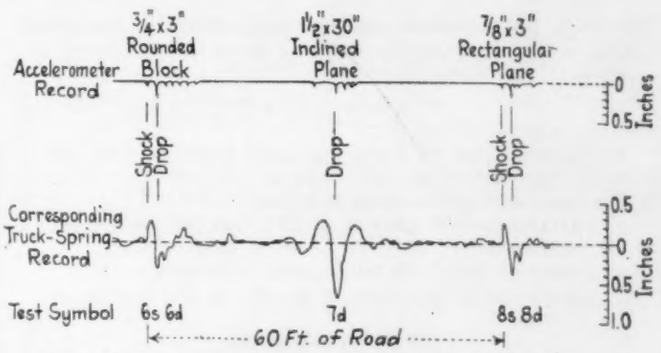
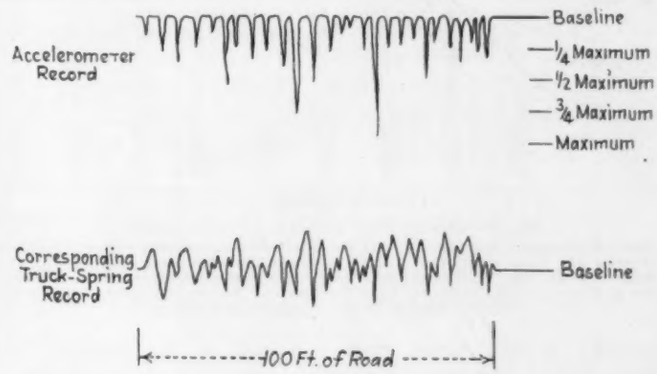


FIG. 6—TYPICAL ACCELEROMETER RECORDS FROM THE ARTIFICIAL OBSTRUCTION TEST
The Process of Converting These Records into Terms of Force Is Also Illustrated

Details	Test-Obstruction Symbol 6s	6d	7d	8s	8d
Unsprung-Weight					
Accelerometer Reading, in.	0.08	0.25	0.18	0.10	0.24
Acceleration, ft. per sec. per sec.	162	506	364	202	486
Mass, *m*, poundals	22.5	22.5	22.5	22.5	22.5
Unsprung-Force, lb.	4,370	12,110	8,915	5,270	11,660
Sprung-Weight					
Spring Reading, in.	0	0.34	0.72	0	0.40
Variation from Static, lb.	0	—1,605	—3,400	0	—1,890
Sprung-Force, lb.	1,625	20	—1,775	1,625	—265
Total Vertical Road-Reaction, lb.	5,995	12,130	7,140	6,895	11,395
Percentage of Static	255	516	304	294	485



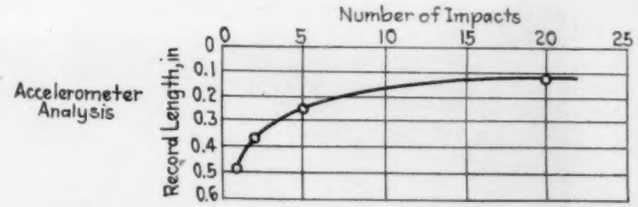


FIG. 7—TYPICAL ACCELEROMETER RECORDS FROM THE HIGHWAY TEST
In Addition to Reproductions of Actual Records the Process of Converting These Records into Terms of Force Is Shown. The Values Computed from Formula (1) Are Tabulated Below

Details	Number of Impacts 1	5	10	20
Accelerometer Reading, in.	0.50	0.25	0.18	0.12
Acceleration, *a*, ft. per sec. per sec.	520	260	187	125
Value of $(a + g)$	552	292	219	157
Mass, *m*, poundals	37.3	37.3	37.3	37.3
Value of $m\ (a + g)$, lb.	20,600	10,900	8,200	5,900
Spring Pressure, lb.	7,800	7,800	7,800	7,800
Total Impact-Force, lb.	28,400	18,700	16,000	13,700

unsprung parts below and not supported by the truck spring. The corresponding total force is computed according to the formula:

$$F = m(a + g) + P \qquad (1)$$

where

a = acceleration of unsprung truck-parts in feet per second per second
F = vertical road-reaction in pounds
g = acceleration of gravity or 32.2 feet per second per second
m = mass of unsprung truck-parts in poundals
P = truck-spring pressure in pounds at the instant of impact

The Accelerometer

The accelerometer, which is shown diagrammatically in Fig. 4, is mounted to follow rigidly the vertical movement of the right rear-wheel of a motor truck by a tight, self-aligning bearing, a, and the instrument slides on guides b on the truck body. The sensitive element is composed of a calibrated coil-spring, c, supporting a weight, d, of known mass. A rod, e, is fastened to this weight and acts as a guide and as a stylus holder. The stylus f records the relative movement of the weight on sensitized paper rolled on a drum, g, that is driven by the truck wheel, therefore the paper and the truck speeds are proportional. A similar record is made by the stylus h which is mounted on the rod i that is actuated by a rack and pinion at the truck spring. A back-stop, j, is arranged above the accelerometer weight to prevent its upward movement beyond the position at rest, and no initial compression is on the spring other than that due to the weight itself.

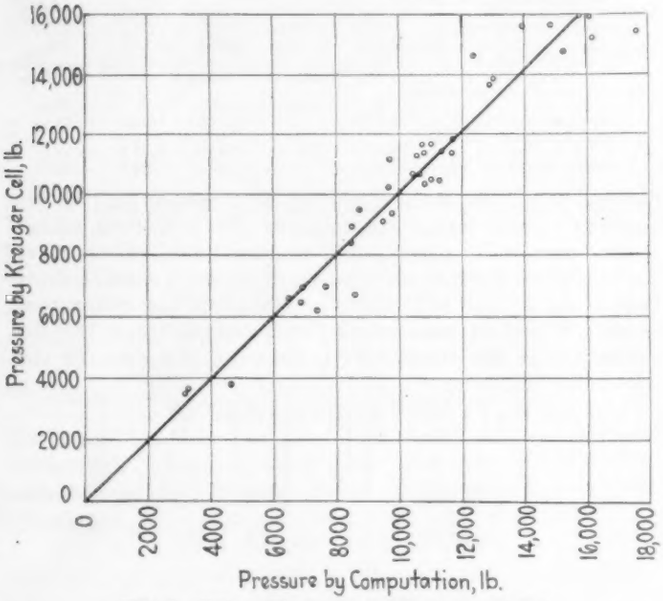


Fig. 8—Check-Test of the Accelerometer

Before Being Used in the Tests, the Accelerometer Was Check-Tested by Measuring the Road Reaction Directly and Comparing It with the Computed Reaction. The Direct Measurement Was Made by a Kreuger Cell Placed in a Pit So As To Be Squarely under a Truck Wheel at the Instant of Impact

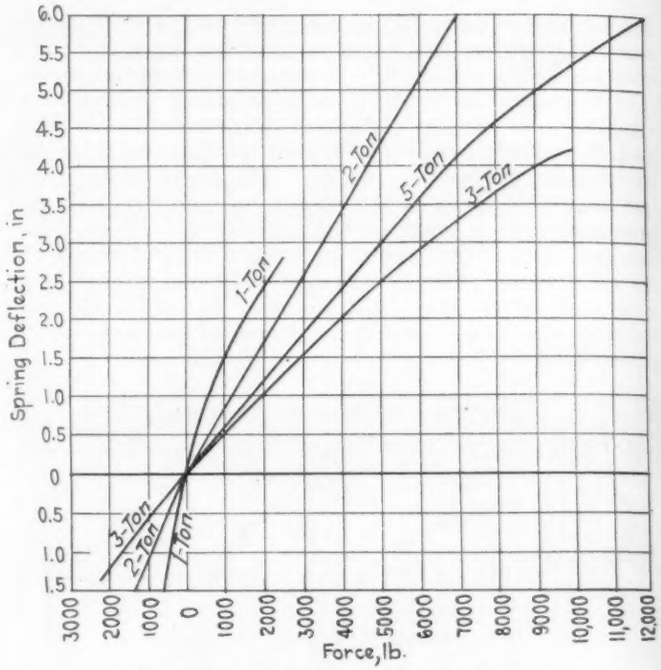


Fig. 9—Truck-Spring Calibration-Curves

These Are Plotted for Deformation Versus Static Load. Before Use in the Tests the Rear Truck-Springs Were Removed, Cleaned, Greased, Calibrated, Provided with Jackets, and Replaced. For Reference, Weight Distributions of the Empty Trucks, Truck Measurements and Specifications Were Recorded

Fig. 5 shows the complete apparatus installed on a truck, and a close-up view of the instrument proper is given in the insert. Typical accelerometer records and the process of conversion of them into terms of force are shown in Fig. 6, which is for artificial obstructions, and in Fig. 7, which is for an actual road-surface.

In reference to Fig. 6, the deviation of the accelerometer record from a straight line is a measure of the acceleration of the unsprung-parts. This acceleration, multiplied by the mass of the unsprung-parts, gives the force of the blow struck by the unsprung-parts. Under

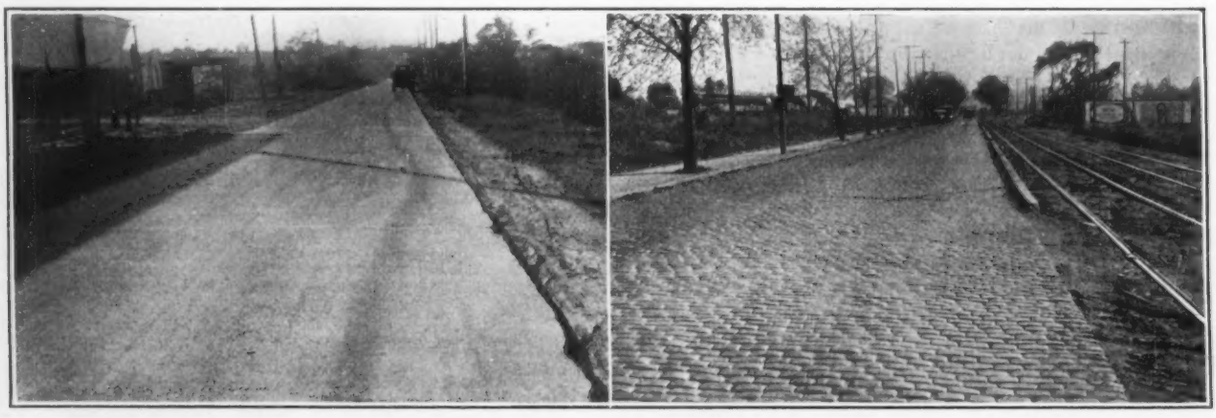


Fig. 10—Highway Test-Sections

The Smooth Concrete-Highway Section Appears at the Left and the Rough Stone-Block Section Is Shown at the Right

static conditions, the truck spring is deflected by the sprung load. At the instant of impact, the position of the truck spring above or below its average base line or static position is a measure of the sprung-weight ac-

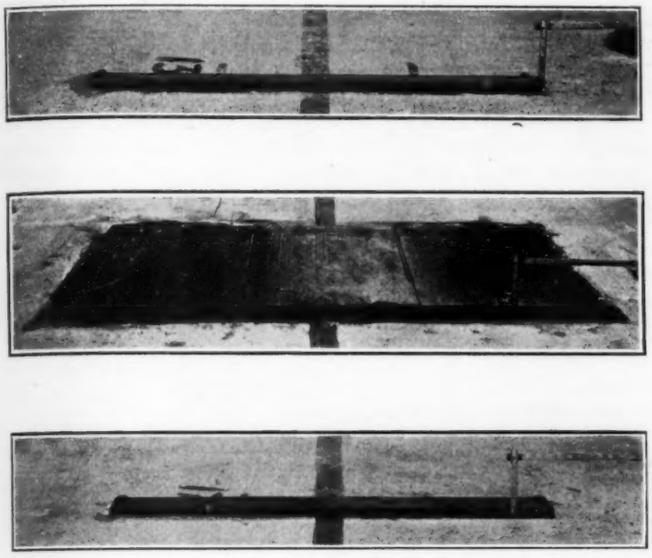


FIG. 11—TYPICAL ARTIFICIAL OBSTRUCTIONS

Varied Types of Steel Obstruction Were Set in Grout on the Very Smooth, Straight and Substantially Level Concrete-Roadway That Was Specially Built for the Tests. The Obstructions Were about 4 Ft. Wide and Were Placed at 30-Ft. Intervals along a Painted Guide-Line on the Road. From Top to Bottom the Obstructions Are the Rounded, the Inclined-Plane and the Rectangular Types

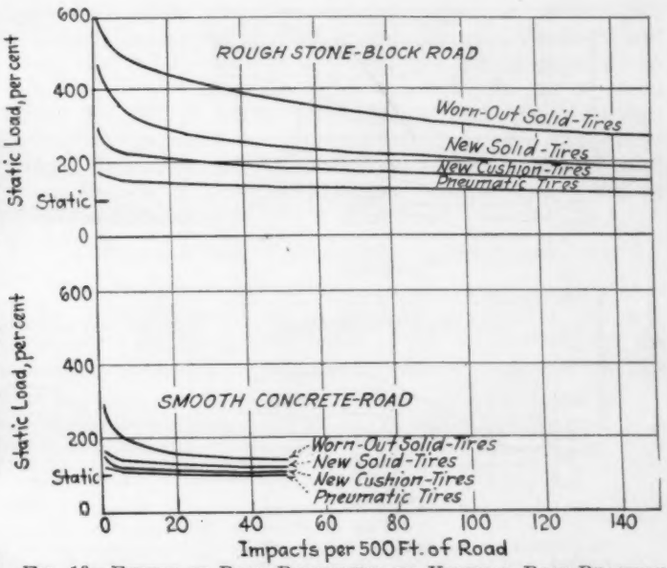


FIG. 13—EFFECT OF ROAD ROUGHNESS ON VERTICAL ROAD-REACTION

The Curves Show Typical Results Obtained on the Highway Test-Sections and Illustrate Clearly That Pneumatic Tires May Make a Rough Road Seem Reasonably Smooth and That Solid Tires in Poor Condition May Make a Smooth Road Seem Unreasonably Rough

tive at the instant of impact. The sum of the unsprung and the sprung-components is the total vertical road-reaction. If this total impact-reaction is divided by the total static-reaction, it can be expressed as percentage of the static load. In the example given in Fig. 6, the total static-load per rear wheel is 2349 lb., of which 724 lb.

VEHICLE	1-TON TRUCK				2-TON TRUCK				3-TON TRUCK				5-TON FOUR-WHEEL TRUCK				5-TON SIX-WHEEL TRUCK				MOTORCOACH				TOTAL			
Type of Tire \ Status of Tests	Completed	Originally Scheduled	Added to Schedule	Additional Desired	Completed	Originally Scheduled	Added to Schedule	Additional Desired	Completed	Originally Scheduled	Added to Schedule	Additional Desired	Completed	Originally Scheduled	Added to Schedule	Additional Desired	Completed	Originally Scheduled	Added to Schedule	Additional Desired	Completed	Originally Scheduled	Added to Schedule	Additional Desired	Completed	Originally Scheduled	Added to Schedule	Additional Desired
Underinflated Pneumatic	1		1		3	3			1	1			1				1	1					4		7	5	5	
Standard Inflated Pneumatic	1		1		3	3			1	1			1	1			1	1					4		7	6	5	
New Cushion	12		12		14	14			10	10														2	36	24	12	2
Cushion, cut-down 1 1/8"					12	12			8	8	2													2	20	20	2	2
Cushion, cut-down 1 5/8"					4		8				6														4		14	
Cushion, cut-down 2"							8				6																14	
Heavy-Duty Cushion													2	2											2		2	
New High-Profile					2	2			2	2														1	4	4		1
High Profile, first cut							2				2																4	
High Profile, second cut							2				2																4	
High Profile, third cut							2				2																4	
High Profile, final cut							2				2																4	
High Profile, worn-out					2	2			2	2															4	4		
Non-Skid					10	10																			10	10		
New Regular					4	4			4	4			4	4						1					12	12		1
Regular, first cut							4				4									1							8	1
Regular, second cut							4				4									1							8	1
Regular, final cut							4				4									1							8	1
Regular, worn-out	1	1			4	4			4	4			4	4											13	13		
Compound							2																	1			2	1
TOTAL	15	1	14		58	54	38		32	32	34		12	9	2		2	2		4			8	6	119	98	96	10

FIG. 12—TIRE AND TRUCK COMBINATIONS ON WHICH DATA ARE NOW AVAILABLE

The Original Field-Records from These Combinations Were All Read and Plotted. The Chart Does Not Include a Number of Auxiliary Tests Such As Those for Temperature, Unsprung-Weight and the Like, or Tests on Tires That Were Redesigned during the Tests

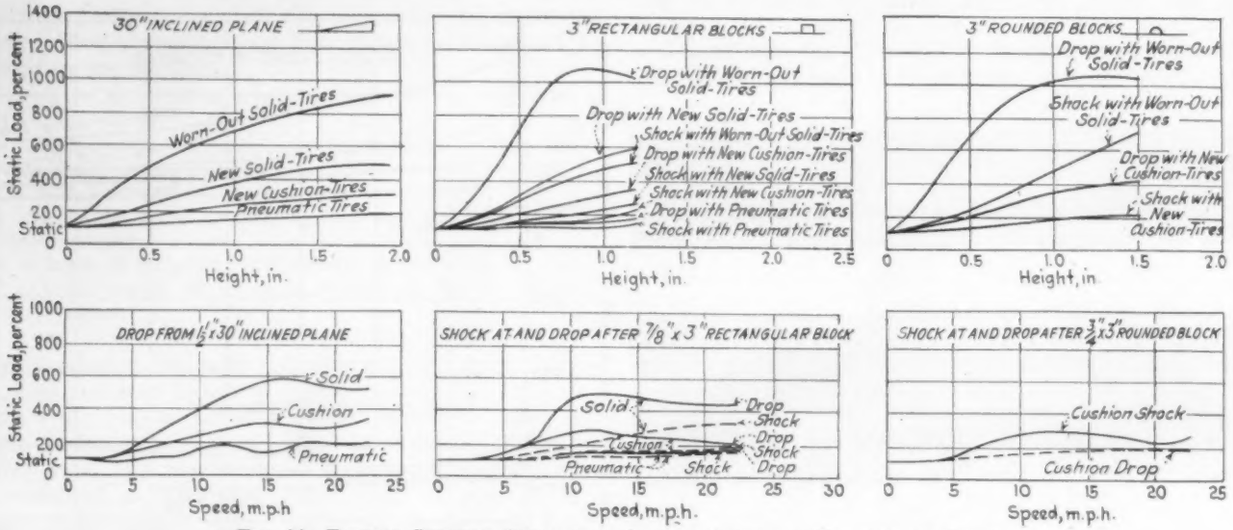


FIG. 14—TYPICAL RESULTS OBTAINED FROM THE ARTIFICIAL-OBSTRUCTION TESTS

The Effect of the Height and the Type of Obstruction on the Vertical Road-Reaction Is Shown in the Upper Group of Curves, and the Lower Group Depicts the Effect of the Type of Obstruction on the Vertical Road-Reaction As Influenced by Truck Speed

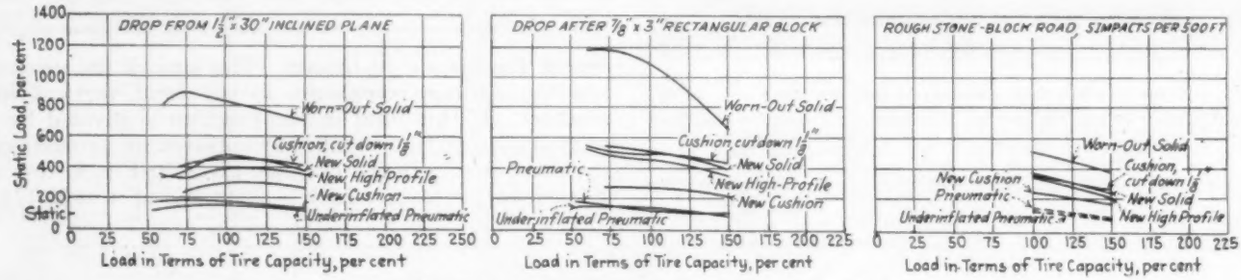


FIG. 15—TEST RESULTS ON DIFFERENT TYPES OF TIRE

The Effect of the Type of Tire on the Vertical Road-Reaction as Influenced by Tire Load Is Brought Out by Three Sets of Curves

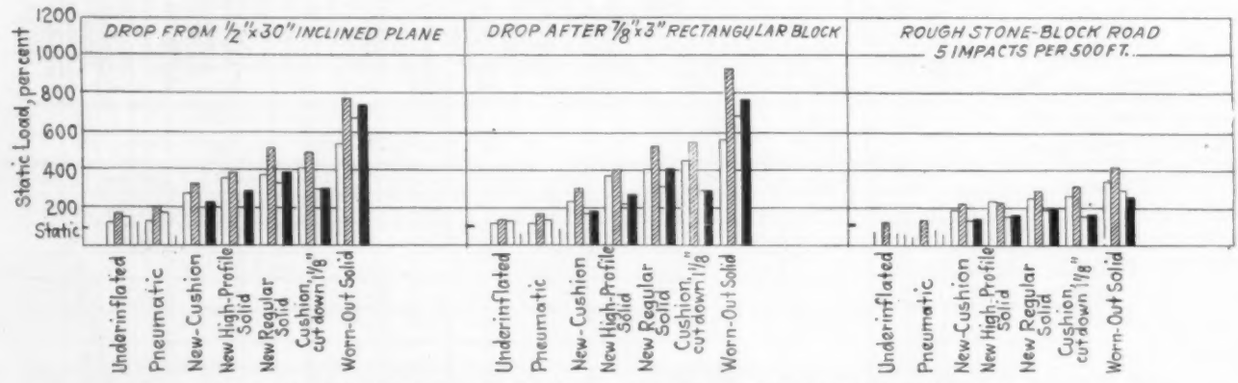


FIG. 16—THE RELATION BETWEEN OVERLOADED AND OVERSIZED DUAL-TIRE EQUIPMENT

The Data Presented Are for the Same Wide Range of Tire Types As Those of Fig. 15 and for Two Different Trucks

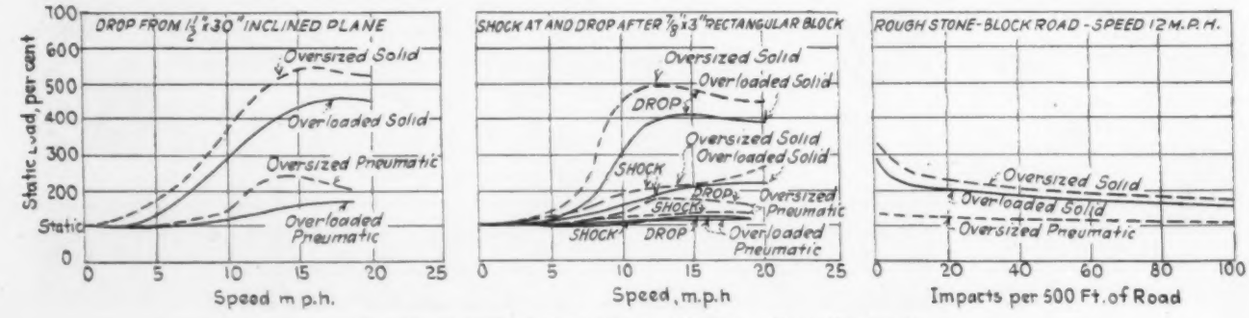


FIG. 17—EFFECT OF TIRE SIZE ON VERTICAL ROAD-REACTION

This Is As Influenced by Speed and by Road Roughness. Only Extremes of New Tire-Equipment Are Shown

is unsprung and 1625 lb. is sprung. The accelerometer rate is 2022 ft. per sec. per sec. per 1 in. of record, and 1 in. of truck-spring record corresponds to a change of 4720 lb.

In reference to Fig. 7, the force of the wheel in striking the road is developed by (*a*) the blow of the parts below and not supported by the truck springs and (*b*) the weight of the parts above and supported by the truck springs. The blow struck by the unsprung-weight (*a*) is found by multiplying its mass by its acceleration. The mass is obtained by weighing, and the acceleration is derived from the record depicted in Fig. 7, to which is added the acceleration of gravity. As to (*b*), the sprung-weight is obtained by weighing. The average position of the truck spring is the same as when the truck is standing still, and the average pressure transmitted through the spring is equal to the weight of the body and load carried by each rear wheel. In the example given in Fig. 7, the sprung-weight was 7800 lb. for a wheel load of 9000 lb. on a certain truck, and the unsprung-weight was 1200 lb. From these data, the unsprung-mass was computed to be 37.3. The accelerometer used had a rate of 1040 ft. per sec. per sec. per 1 in. of record, and formula (1) was utilized.

Accelerometer Calibration and Check-Test

The characteristics of this accelerometer are such that the displacement of its weight, as recorded on the sensitized paper, is proportional to the acceleration of the truck wheel. The calibration factor depends on the

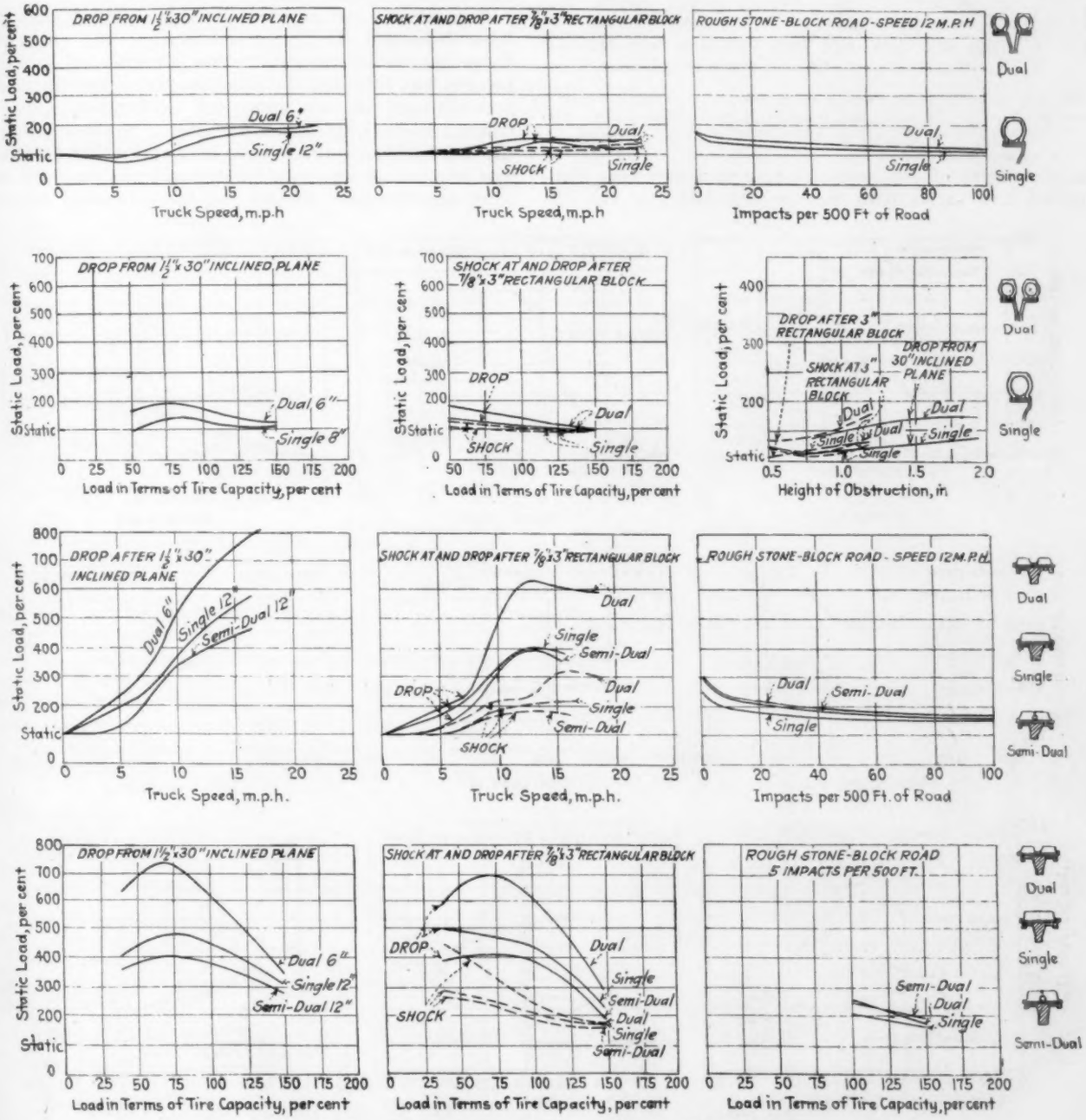


Fig. 18—Relations between Single and Dual Tire-Mountings

These Are for Two Sizes of Truck and Cover Both Pneumatic and Solid Tires. The Effect on the Vertical Road-Reaction As Influenced by Truck Speed Is Shown, for a 2-Ton Truck, in the Upper View, and That for the Same Truck As Influenced by Tire Load and the Height of the Obstruction Appears in the Upper Central View. In the Lower Central View, the Effect on the Vertical Road-Reaction As Influenced by Truck Speed Is Shown for a 5-Ton Truck, and That for the Same Truck As Influenced by Tire Load Is Illustrated in the Lowest View

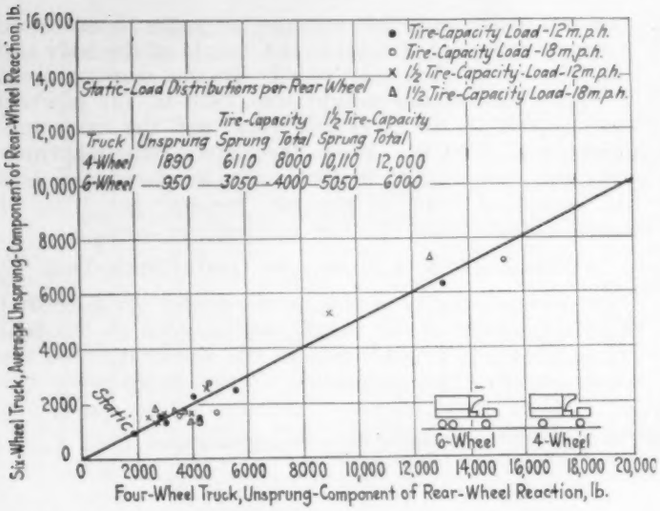

Tire-Capacity Load-12m.p.h.
Tire-Capacity Load-18m.p.h.
1½ Tire-Capacity-Load-12m.p.h.
1½ Tire-Capacity Load-18m.p.h.
Static-Load Distributions per Rear Wheel
Truck | Unsprung | Tire-Capacity Sprung | Tire-Capacity Total | 1½ Tire-Capacity Sprung | 1½ Tire-Capacity Total
4-Wheel | 1890 | 6110 | 8000 | 10,110 | 12,000
6-Wheel | 950 | 3050 | 4000 | 5050 | 6000
Static
6-Wheel
4-Wheel
Six-Wheel Truck, Average Unsprung-Component of Rear-Wheel Reaction, lb.
Four-Wheel Truck, Unsprung-Component of Rear-Wheel Reaction, lb.

FIG. 19—RELATIONS BETWEEN A FOUR AND A SIX-WHEEL TRUCK Each Is of 5-Ton Capacity and Pneumatic Tires Were Used. The Unsprung-Components of Road Reactions Are Compared

characteristics of the accelerometer spring-weight combination and varies with the characteristics of the impressed acceleration from the truck wheel. The accelerometer spring-weight characteristics are determined accurately and that combination is selected which is best suited to the accelerations to be measured. The characteristics of the impressed acceleration are influenced by the natural characteristics of the tire equipment and the unsprung-weight of the truck in the case of the wheel dropping onto a plane surface. In the case in which the wheel passes over a relatively narrow obstruction at comparatively high speed, an additional correction should be made which is dependent on the duration of this condition of shock. Calibration factors for various accelerometer spring-weight combinations have been determined for use with the full range of tire equipments included in the tests. These factors have been established analytically, indirectly and directly.

Formulas, substantiated by experimental data, have been developed for the determination and checking of these calibration factors. The analysis of space-time records has afforded the fundamental determinations of accelerations in the empirical calibrations, and that method of analysis which assumes a parabolic shape of the original space-time curve over an appreciable period was selected as representing the average constant maximum acceleration. Should the instantaneous maximum

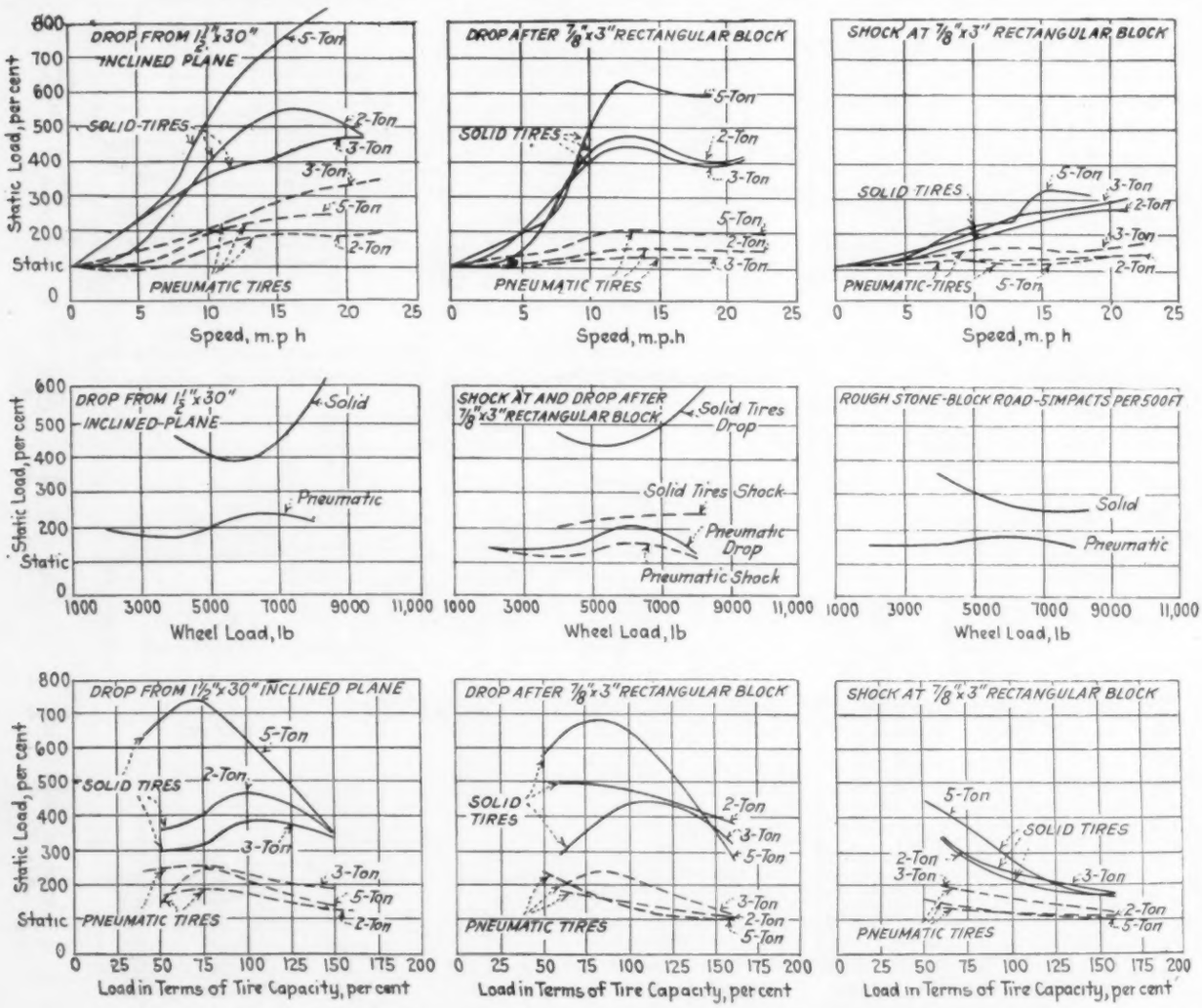


FIG. 20—EFFECT OF TRUCK CAPACITY OR SIZE ON THE VERTICAL ROAD-REACTION New Solid and Pneumatic Tires Were Used. In the Top Group, the Influence of Speed in Passing over the Representative Artificial Obstructions Is Shown. In the Middle Group, the Truck Size Is Represented by Its Rear-Wheel Load When the Respective Tires Are Loaded to Capacity. In the Lowest Group, the Influence of Tire Load When Passing over the Representative Artificial Obstructions Is Illustrated, the Loads That Correspond to the Rated Capacities of the Trucks Being Indicated

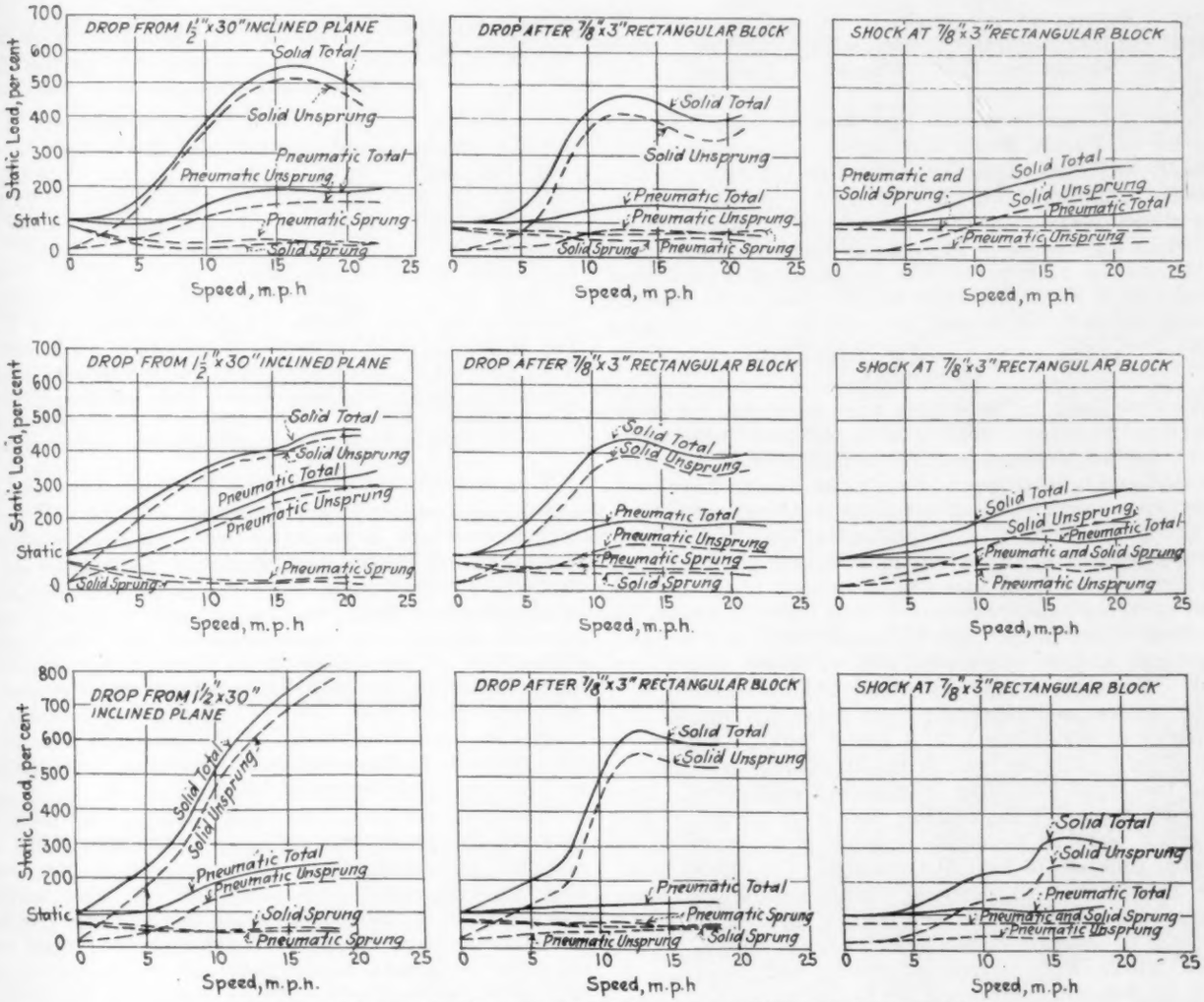


FIG. 21—RELATIVE IMPORTANCE OF SPRUNG AND OF UNSPRUNG COMPONENTS
These Components of the Vertical Road-Reactions, As Influenced by Truck Speed over the Representative Artificial Obstructions, Are Compared, from the Top Down, for 2, 3 and 5-Ton Truck. New Solid and Pneumatic Tires Are Again Compared, Each Tire Being Loaded to Capacity

be desired, it can be obtained from the calibration data already on hand and will vary from 100 to about 115 per cent of the parabolic maximum, according to conditions within the test range. On the above basis, for the test conditions to date, the errors in the measurement of acceleration generally will be within 10 per cent for all conditions of drop and for conditions of shock up to 10 m.p.h. For conditions of shock between 10 and 15 m.p.h., the error may be 15 per cent; between 15 and 20 m.p.h. for the condition of shock, it may be 20 per cent. These values are considered conservative and are based on calibration work conducted by a special accelerometer subcommittee, which covered adequate ranges of speed and obstruction with pneumatic and with new solid-tires. The complete procedure and results of the accelerometer calibration are to be made the subject of a separate

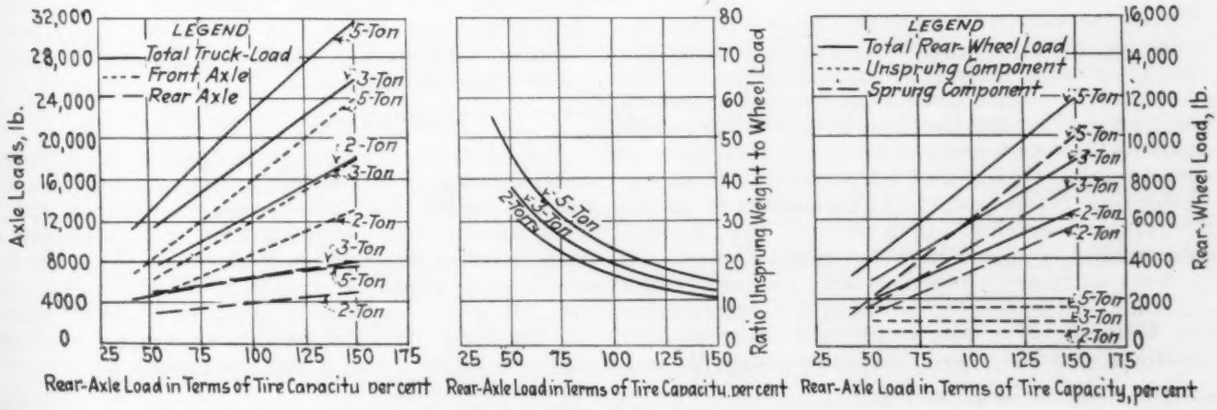


FIG. 22—STATIC DISTRIBUTION OF TRUCK WEIGHTS
The Trucks Were Equipped with Dual Pneumatic-Tires of Rated Sizes

paper. References are made to an article by L. W. Teller, entitled Accurate Accelerometers[3], and to a paper by F. H. Norton and E. P. Warner on Accelerator Design[4].

After this accelerometer had been developed by the Bureau of Public Roads and before being used in the tests, it was check-tested by measuring the road reaction directly and comparing it with the computed reaction. The direct measurement was made by a Kreuger cell placed in a pit so as to be squarely under a truck wheel at the instant of impact. The results of this check-test are shown in Fig. 8, in which impact pressures measured during motor-truck impact are plotted from tabulated data[5].

Equipment

The tires used in these tests were furnished by seven American manufacturers. The types used were pneumatic; cushion and heavy-duty cushion; and high-profile, non-skid and regular types of solid tire. Tests have been made with new and worn-out tires and with new tires cut to various heights. The pneumatic tires were tested at standard and at three-fourths standard air-pressures. The sizes varied from 32 x 3½ in. to 40 x 14 in. and the rated carrying-capacities varied from 1300 to 11,200 lb. per tire. They were used in single, dual and tandem mountings and as overloaded and oversized tire-equipment.

The trucks used represent four American makes, the capacities of which are 1, 2, 3, and 5 tons. Loads were applied up to 150 per cent of the tire-carrying capacity, using the types and sizes in standard equipment. The pay loads were 100-lb. weights that were placed within the truck body in a definite manner and according to accepted practice in load distribution. The wheel loads were measured with portable road-scales, which were calibrated frequently. In addition, a number of loads were sent to accurate platform-scales for checking.

The trucks were driven at speeds varying from 3 m.p.h. by 3-m.p.h. increments up to the maximum speed obtainable under the load and the test conditions. Speeds were determined by timing measured runs with a stop-watch, and were checked for variation by the truck speedometer. Any run that showed a variation of more than ½ m.p.h. from the average speed was discarded, that test being re-run. Before use in the tests the rear truck-springs were removed, cleaned, greased, calibrated, provided with jackets and replaced. For reference, weight distributions of the empty trucks, truck measurements and specifications were recorded. The truck-spring calibration-curves are shown in Fig. 9.

Roads

To include actual road-conditions, two 500-ft. lengths of nearby highways were selected as test road-sections to represent extremes likely to be encountered by through commercial traffic. One of these is an example of smooth concrete-construction, and the other is an old stone-block pavement. A 16-wheel profilometer showed an average cumulative vertical-variation of 2.5 in. per 100 ft. on the smooth concrete-section, and of 18.2 in. per 100 ft. on the rough stone-block section. Both sections are straight and substantially level and have but slight crowns. In general, tests on these two sections were confined to tire capacity and 1½-tire-capacity loads at a representative speed of 12 m.p.h. The number of impacts, or vertical road-reactions, produced and the magnitudes thereof were determined. The two highways are shown in the two views of Fig. 10.

Artificial Obstructions

To provide for duplication of test conditions, a very smooth, straight, and substantially level concrete roadway was specially built for these tests, and various steel obstructions were set in grout on it and secured by bolts. These obstructions included 30-in. inclined planes with rises of 13/16, 1½ and 1 15/16 in. respectively; 3-in. rectangular-cross-section blocks with heights of 9/16, ⅞ and 1⅛ in. respectively; and rounded segmental blocks having 3-in. chords or bases and heights of ¾ and 1½ in. respectively. These obstructions were about 4 ft. wide and were placed at about 30-ft. intervals along a painted guide-line on the road. Fig. 11 shows typical obstructions.

Data Obtained

Tire and truck combinations on which data are now, and will be, available are shown in Fig. 12. The original field-records from these combinations are all read and plotted. Sprung and unsprung-components of the vertical road-reaction at any of the artificial obstructions can be obtained from the resultant curves and, by interpolation, for any reasonable height of the same types of obstruction at any speed up to truck maximum for all loads, including four loads on standard-size tires and one load on oversize tires. On the test highway-sections, the magnitudes and frequencies of the reactions are obtainable for two loads on standard-size tires and one load on oversize tires, the speed being 12 m.p.h.

From the foregoing material certain conditions are selected on which the data are computed fully and recorded on standardized forms as sprung-component, unsprung-component and total vertical road-reaction; and the ratio of the road reaction to the static tire-load, expressed as a percentage. These computed tests show the effect of variable load at constant speed over variable heights of representative obstructions, and the effect of constant load at variable speeds over representative obstructions. For the highway test-runs, certain numbers of impacts per 500 ft. of road are computed.

An almost unlimited number of comparisons can be made which will show the influence of the several variables on vertical road-reaction. In the accompanying curves, an attempt has been made to present the data in such form that general comparisons can be drawn among these variables. Sufficient time and space may not be allotted to make exhaustive studies of all conditions; however, the original data in its plotted form and the standardized computed portions thereof are accessible to those who have a proper interest in making detailed studies or comparisons. In presenting this report the data are submitted as found, and the curves faithfully follow their plotted points.

Highway and Obstruction Tests

Fig. 13 shows typical results obtained on the highway test-sections. It shows clearly that pneumatic tires may make a rough road seem reasonably smooth and that solid tires in poor condition may make a smooth road seem unreasonably rough. It shows also that the forces developed on a road which is built and maintained smooth are, for given equipment, appreciably lower than the corresponding forces developed on a very rough road, although either road is not uncommon in present-day commercial-traffic.

The charts reproduced as Fig. 14 show typical results obtained from the artificial-obstruction tests. The

[3] See *Public Roads*, December, 1924, p. 1.
[4] See National Advisory Committee for Aeronautics Report No. 100.
[5] See *Public Roads*, December, 1924, p. 9, Table 2.

effects of the three types of obstruction throughout their full ranges of height and the influence of the speed of the truck when passing over representative obstructions of these types are shown for typical tire-conditions.

Effects of Tire Equipment

The next group of figures is concerned directly with tire equipment. Fig. 15 shows test results on nearly every type of tire. Fig. 16 illustrates, for the same wide range of tire types, the relation between overloaded and oversized tires on two different trucks. Fig. 17 depicts a similar effect of tire size as influenced by the truck-speed, only extremes of new tire-equipment being given. It shows also the effect of tire size on an actual highway-section. Fig. 18 shows in various ways the relations between single and dual tire-mountings on two sizes of truck and covering both pneumatic and solid tires.

Truck Effects

A relation between a four-wheel and a six-wheel truck, each of 5-ton capacity, is shown in Fig. 19, pneumatic tires being used. The three groups of charts reproduced as Fig. 20 show the effect of truck capacity, or size, on the vertical road-reaction, new solid and new pneumatic

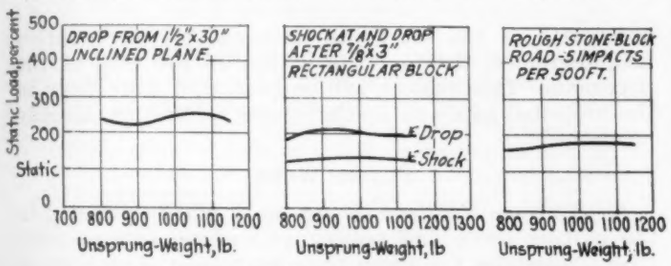


Fig. 23—Results of Varying the Unsprung-Weight
Data Obtained from a Few Tests Made To Determine the Effect of Varying the Unsprung-Weight of the Truck Are Presented

being the tire equipments. In the top group, the influence of speed over the representative artificial-obstructions is shown. In the middle group, the truck size is represented by its rear-wheel load when the respective tires are loaded to capacity. In the lowest group, the influence of tire load when passing over the representative artificial-obstructions is shown, the loads that correspond to the rated capacities of the trucks being indicated. Fig. 21 shows in the three sets of charts the relative importance of the sprung and the unsprung-components of the vertical road-reactions, as influenced by speed over the representative artificial-obstructions, for 2, 3 and 5-ton trucks respectively. New solid and new pneumatic tires are again compared, each tire being

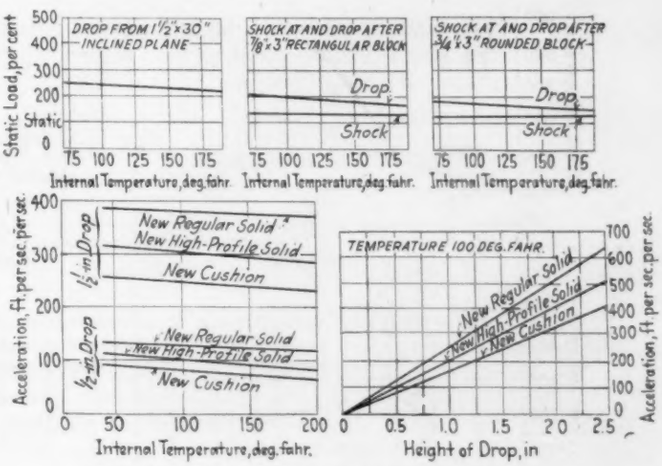


Fig. 25—Internal Tire-Temperature Effects
The Curves in the Upper Group Show the Effect of Internal Tire-Temperature on the Vertical Road-Reaction As Obtained from the Truck Test over the Artificial Obstructions, Those in the Lower Group Being Illustrative of Internal Tire-Temperature and Height of Drop Effects on Wheel-Impact Reaction As Obtained on an Impact-Testing Machine

loaded to capacity. The static distributions of truck weights are shown in Fig. 22.

Miscellaneous Observations

A few tests have been made to determine the effect of varying the unsprung-weight of the truck, and the results are shown in Fig. 23. Although, for the test conditions, no great effect apparently is to be noticed in varying the unsprung-weight, it may perhaps be desirable to make further tests along this line. It is mentioned that, from a cushioning viewpoint, the combination of a low-pressure balloon or underinflated pneumatic-tire, a relatively heavy unsprung-weight and a comparatively flexible truck-spring might substantially eliminate all but the most severe road roughness.

The effect of tire composition, or the compound of rubber used in the manufacture of tires, is shown in Fig. 24. This comparison includes both new and worn-out solid-tires at varying loads.

A brief investigation concerning the effect of internal tire-temperature was made. The upper group of chart in Fig. 25 shows the results of the truck test over the artificial obstructions, and the lower group shows results obtained on an impact-testing machine.

During the tests a certain type of new tire that had a non-skid-tread of a design now obsolete was used on a truck as dual equipment. The tires were placed on the wheel with the tread designs opposite and then with the

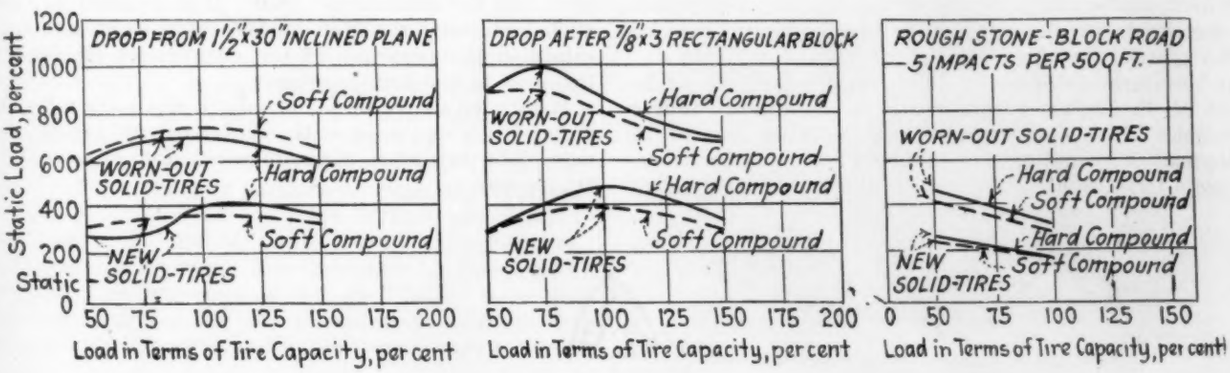


Fig. 24—Effect of Hardness of Tires
These Curves Refer to the Effect of Tire Composition, or Hardness of Tire, on the Vertical Road-Reaction, As Influenced by Tire Load. This Comparison Includes both New and Worn-Out Solid-Tires at Varying Loads

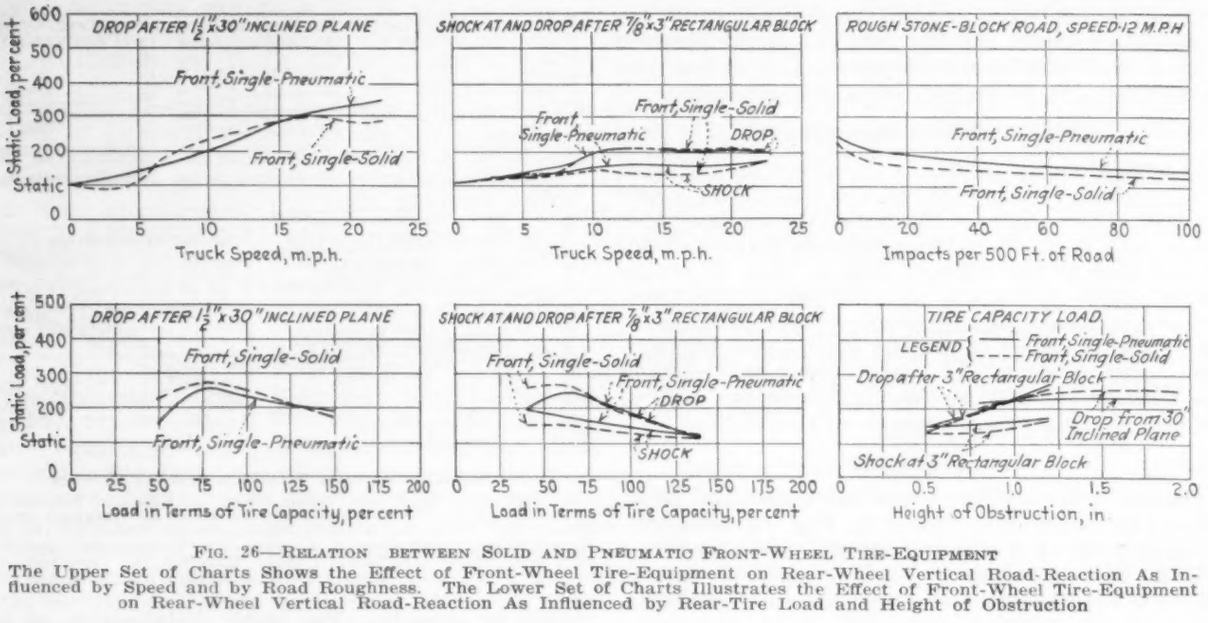


FIG. 26—RELATION BETWEEN SOLID AND PNEUMATIC FRONT-WHEEL TIRE-EQUIPMENT
The Upper Set of Charts Shows the Effect of Front-Wheel Tire-Equipment on Rear-Wheel Vertical Road-Reaction As Influenced by Speed and by Road Roughness. The Lower Set of Charts Illustrates the Effect of Front-Wheel Tire-Equipment on Rear-Wheel Vertical Road-Reaction As Influenced by Rear-Tire Load and Height of Obstruction

tread designs staggered. The markings on these tires were unusually deep and, by varying the mountings as stated previously, an exceptional variation in cross-sectional rubber was obtained. This change in mounting was of itself sufficient to reduce the impact reaction from 3600 to 1200 lb. at each repetition of tread design, or about 8 in., along a smooth concrete-roadway.

A test was made to determine the relation between solid and pneumatic-tire equipment on the front wheels of a 3-ton truck, the rear wheels being equipped with pneumatic tires. The results of this test are offered, as found, for whatever value they may have for automotive engineers. The upper set of charts in Fig. 26 shows the influences of truck speed and road roughness, and the lower set shows the influences of rear-wheel load and of the height of artificial obstructions.

The distribution of pay load was 80 per cent to the rear axle and 20 per cent to the front axle, except for the overload and the oversize load on the 5-ton, four-wheel truck, which distribution was 85 per cent to the rear axle and 15 per cent to the front axle. It was found, however, that if the rear wheels were loaded to the proper amount, a variation of several hundred pounds on the front axle produced no appreciable change in the rear-wheel impact.

It is noted in the foregoing comparisons that there appears to be a critical speed between 12 and 15 m.p.h. at which, particularly on the drops, for any equipment, the maximum or an approach to the maximum road-reaction exists.

As the duration of motor-truck impact-forces is of interest to designing engineers, it is mentioned that a pneumatic tire is, during impact, deflected beyond its static-load deformation for about 0.08 sec., and a worn-out solid-tire for about 0.02 sec. During approximately one-fourth of the foregoing intervals, the acceleration and, therefore, the force, is within 10 per cent of the maximum. This subject will be presented more fully in the projected paper on accelerometer calibration, already mentioned.

FUTURE WORK

As at present outlined, future work will be directed to the cutting down and testing of cushion and of solid tires. Schedules for these tests have been submitted to and approved by the cooperative committee. A combination dual tire-equipment for a rear truck-wheel which includes a 36 x 6-in. pneumatic-tire and a 36 x 4-in. high-profile solid-tire has been selected for testing on the 2-ton truck. The combined capacity-load will be 3900 lb. per wheel. This work has also been approved by the committee.

Additional tests with such recently designed tires as properly come within the scope of these tests have been authorized, provided the tires have been placed in general service. The work to be done on the high-speed motorcoach-chassis, although approved, has not been scheduled definitely because the motorcoach and the tire-equipment have not been specified by the committee. The foregoing outline and authorized tests are arranged in convenient schedules and will proceed as fast as weather and other conditions permit. They probably will extend well into the summer of 1926. It is planned to conduct such additional research on the instrumentation as will establish the accuracy of the data under all conditions included in the test program.

It may be desirable to include in the tests a six-wheel motor-truck equipped with solid tires, to procure accurate data for such a combination for present or for future use.

Instrumentation and Results of Riding-Qualities Tests

By Roy W. Brown[1]

Semi-Annual Meeting Paper *Illustrated with* Photographs and Drawings

ABSTRACT

ULTIMATE successful measurement of riding-qualities is indicated by the design and construction of several new accelerometers. Experimental work with these new instruments has served to emphasize the desirable and the undesirable instrument-characteristics essential to accuracy, and thrown light upon some conflicting results heretofore obtained. One of the chief detriments to the development of accurate riding-qualities instruments has been the lack of satisfactory calibration. In the past, space-time curves have been used largely for calibration but, from the viewpoint of accuracy, these curves generally are acknowledged to be unsatisfactory.

An elaborate machine has been constructed which will produce simple harmonic-motion to a very high degree of accuracy. This machine provides a convenient and highly accurate method of calibrating accelerometers in terms of known fundamentals and, in combination with a method for inter-comparing different instruments under simulated road-conditions, it enables instrument calibration through the entire range of vibrations caused by road irregularities.

Measurements of axle accelerations and displacements indicate the need of concentration at this time on the correlation of the various factors entering into riding-qualities. However, a finite evaluation cannot be reached without investigation of physical and mental effects. The need for such an investigation is apparent.

EFFORTS to establish a standard measure of riding-qualities that will enable rapid, accurate and convenient measurements of the vibrations occurring when a motor vehicle is passing over the road has resulted in the introduction of several new instruments. Apparatus has been developed also for the calibration of riding-qualities instruments in terms of known fundamentals. These, with studies of the psychological and physiological effects of vibration, offer an ultimate solution to the problem, and it is thought that this represents a distinct step toward the attainment of a complete solution of the riding-qualities complex.

New Accelerometers

The conception of the contact type of accelerometer has removed many of the difficulties heretofore experienced in the measurement of vehicle accelerations. A design made by me[2] was followed by two others; one was by Dr. Benjamin Liebowitz[3] and the other by Dr. H. C. Dickinson[3]. The actuating portions of these instruments, shown in Fig. 1, indicate the wide latitude permissible in detail design, but that still will secure rigid adherence to fundamental principles. The three new single-element contact-type accelerometers shown in Fig. 1 were developed independently and are of radically different detail-design, but all comply with the same fundamentals, calibrate alike and agree when used to measure the same acceleration. These instruments were all made with a specific purpose in view and are limited in application to recurrent accelerations of approximately similar magnitude.

In an effort to secure a practical instrument suitable for general application, a single-cylinder experimental model was designed and constructed as shown in Fig. 2. This construction secures a compact, rugged, practical instrument capable of operating magnetic counters and recorders. The weight *A*, supported on the adjustable spring *B* by two cantilever springs *C* and *D*, so as to operate between the lower adjustable stop *E* and an upper stop, actuates a pair of electrical contacts when the instrument is accelerated. The contacts and the upper stop are within the barrel *F*, which also houses an electromagnet to secure quick make-and-break of the con-

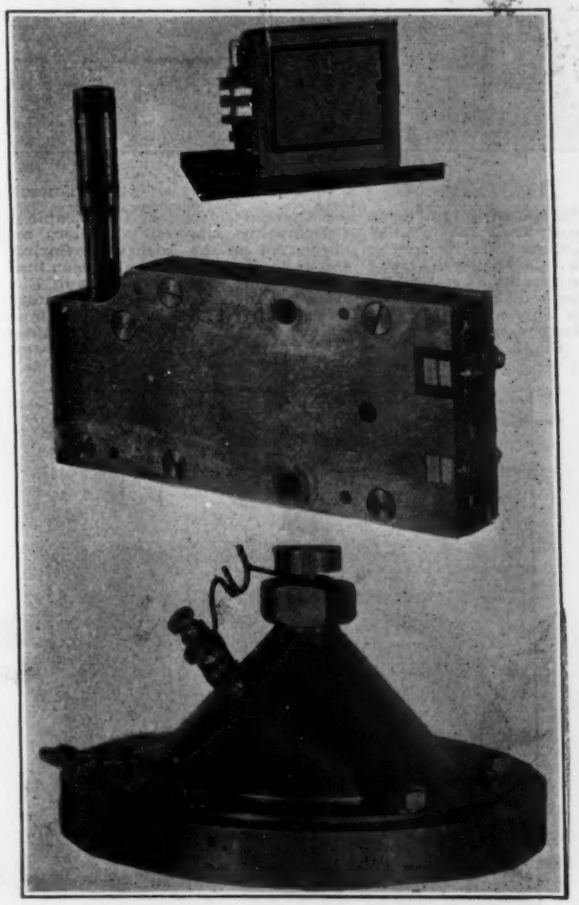


Fig. 1—New Single-Element Contact-Type Accelerometers

These Three Instruments Were Developed Independently and Are of Radically Different Detail-Design; but All Comply with the Same Fundamentals, Calibrate Alike and Agree When Used To Measure the Same Acceleration

[1] In charge of engineering laboratories, Firestone Tire & Rubber Co., Akron, Ohio.

[2] See The Journal, December, 1925, p. 546.

[3] See The Journal, March, 1926, p. 248.

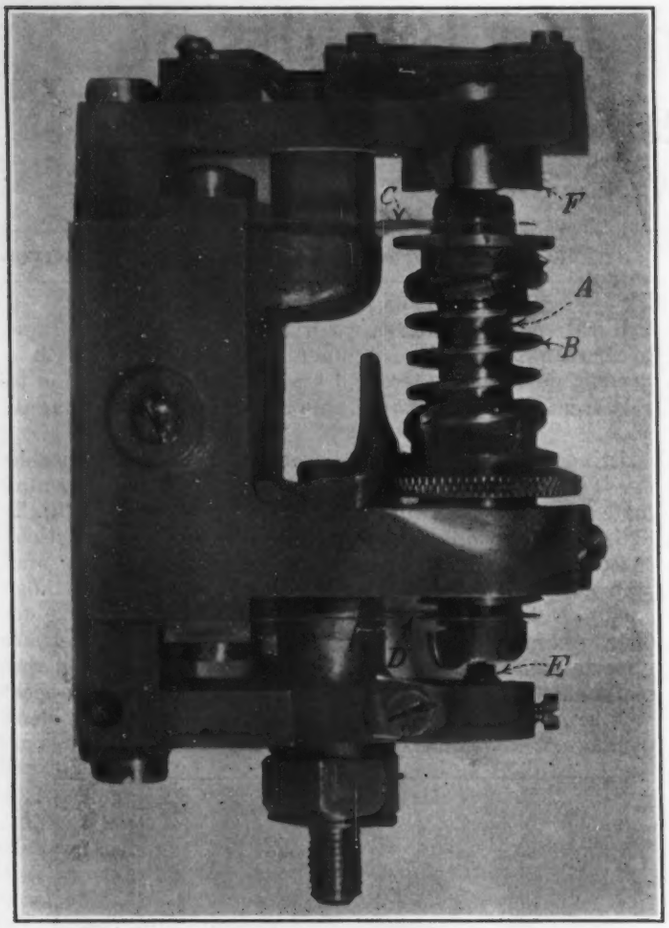


FIG. 2—IMPROVED EXPERIMENTAL CONTACT-ACCELEROMETER

This Construction Secures a Compact, Rugged, Practicable Instrument That Is Capable of Operating Magnetic Counters and Recorders. The Weight *A*, Supported on the Adjustable Spring *B* by Two Cantilever Springs *C* and *D* So As To Operate between the Lower Adjustable Stop *E* and an Upper Stop, Actuates a Pair of Electrical Contacts When the Instrument Is Accelerated. The Contacts and the Upper Stop Are Within the Barrel *F*, That Also Houses an Electromagnet, Whose Function It Is To Secure Quick Make-and-Break of the Contacts during the Operation of the Instrument

tacts. The performance of this experimental instrument was so encouraging that it was immediately superseded by a multiple-element contact-accelerometer of similar design, the actuating section of which is shown in Fig. 3. Ten elements similar to that shown in Fig. 2 are assembled to constitute one instrument. Magnetic counters or recorders can be used to indicate the opening of the contacts. Each element can be adjusted to open the contacts at any value of acceleration up to the maximum for which the springs are designed.

CONTACT-ACCELEROMETER RECORDING-DEVICES

Several methods of indicating, recording or integrating contact-accelerometer readings are available. The telephone receiver and the neon-filled lamp are equally satisfactory for laboratory service with single-element instruments when making observations of repeated accelerations. For road service, especially designed magnetic counters and recorders are satisfactory. Electrolytic integrating ampere-hour meters have been considered as a means of securing a totalized value of acceleration and time; however, to secure reasonable accuracy by this method requires a precision of operation of the accelerometer contacts which has not as yet been obtained.

The difficulty in designing instruments to record maximum acceleration lies in the exceedingly small time-interval through which the maximum acceleration occurs. For instance, a solid tire striking a rectangular obstruction 1 in. high and 3½ in. wide at 9 m.p.h. gives an acceleration to the axle lasting approximately 0.0010 sec. and, when passing over the obstruction and striking the ground, gives an acceleration lasting approximately 0.0007 sec. Both these time values are based upon an approach to within 5 per cent of the maximum acceleration. The true maximum occurs over an appreciably shorter interval. It is obvious that both the accelerometer and its recording mechanism must be capable of operating within this time interval.

Several experimental counters have been constructed. It has been found that the combination of a delayed action in the accelerometer contact and a spring-actuated escapement in the counter will give satisfactory operation. In Fig. 4, an experimental counter is illustrated which was constructed by removing the balance-wheel

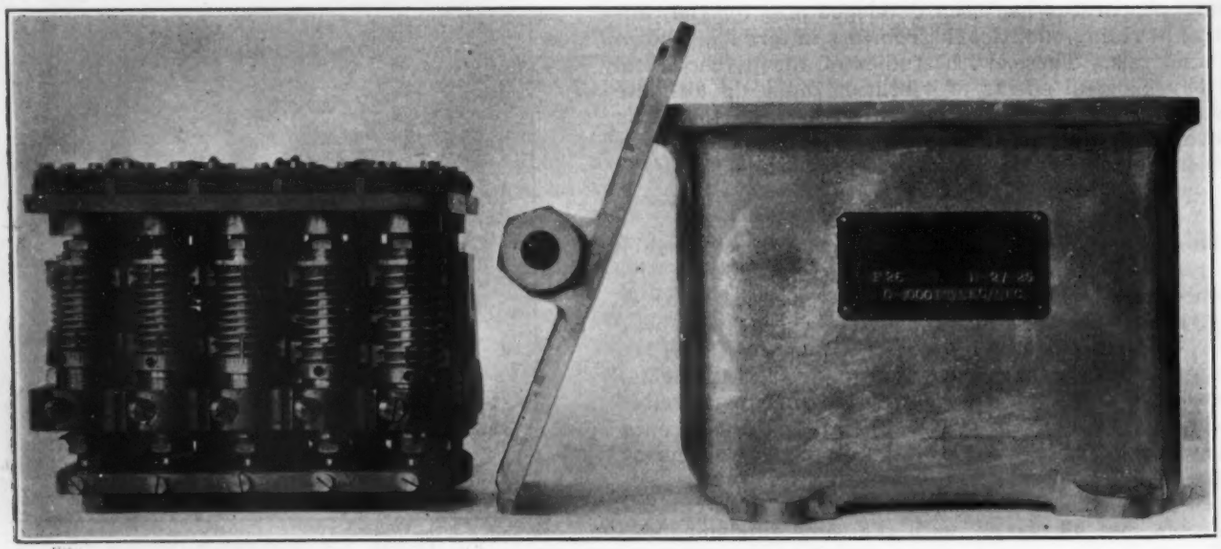


FIG. 3—MULTIPLE-ELEMENT CONTACT-ACCELEROMETER

Ten Elements Similar to That in Fig. 2 Are Assembled To Constitute One Instrument. Magnetic Counters or Recorders Can Be Used To Indicate the Opening of the Contacts. Each Element Can Be Adjusted To Open the Contacts at Any Value of Acceleration Up to the Maximum for Which the Springs Are Designed

from a conventional stop-watch and actuating the escapement by a small differential electromagnet that was connected to a battery and to the accelerometer contacts. Each time the accelerometer contacts open, the escapement is released and the second-hand moves forward an amount equivalent to 1/5 sec. In this type of counter, it is necessary only to maintain a break in the electrical

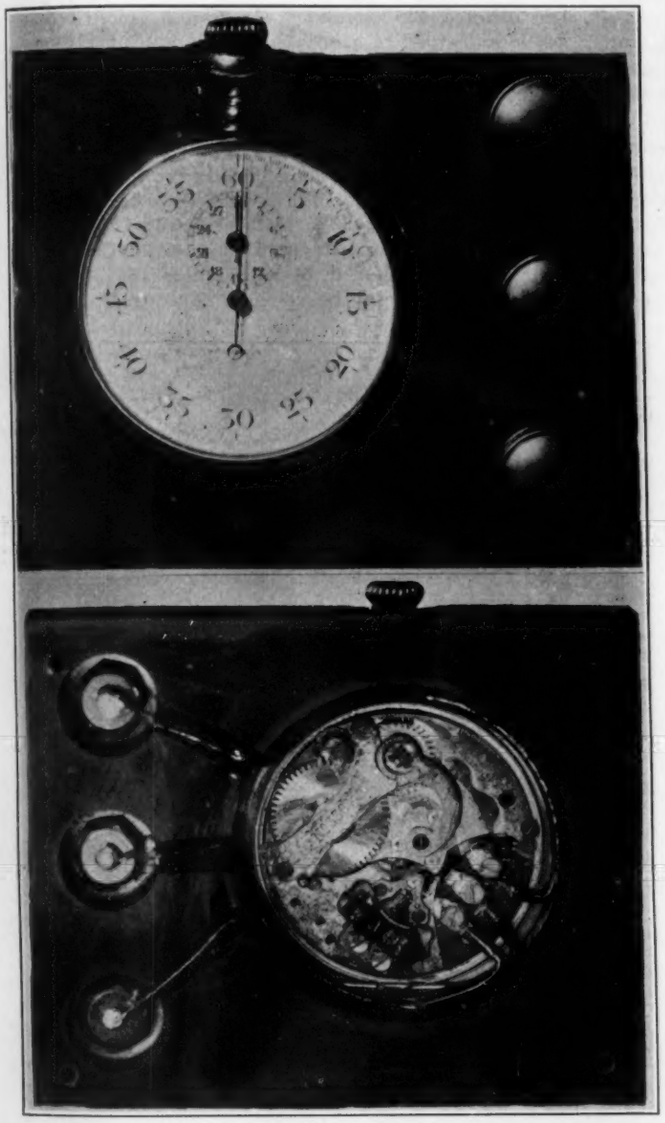


FIG. 4—MAGNETIC COUNTER MADE FROM A STOP-WATCH

The Balance-Wheel of the Watch Was Replaced by a Small Differential Electromagnet and Was Connected to a Battery and to the Accelerometer Contacts. Each Time the Accelerometer Contacts Open, the Escapement Is Released and the Second-Hand Moves Forward an Amount Equivalent to 1/5 Sec.

circuit for a sufficient length of time to disengage the escapement pallet, the mainspring in the watch movement carrying the escapement through its travel. This construction also enables operation of the counter with the minimum current through the accelerometer contacts.

ACCELERATION RECORDER

A chronograph recorder has been constructed, as shown in Fig. 5, for use with multiple-element contact-type accelerometers. This instrument consists of a series of three drums driven by a precision constant-speed motor with gearing suited to secure paper speeds of 0.1, 1.0 and 30.0 in. per sec. A series of 14 magnets is arranged to

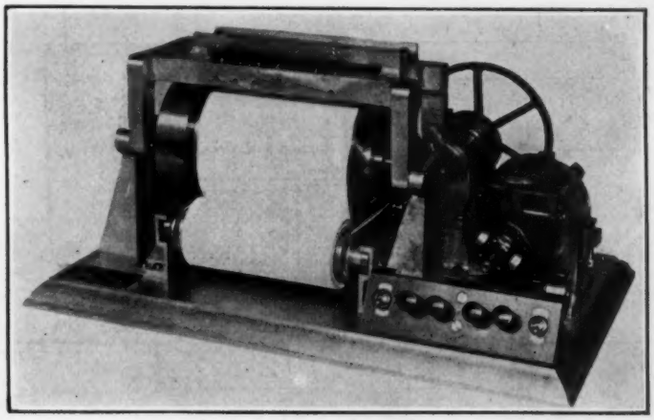


FIG. 5—ACCELEROMETER CHRONOGRAPH

A Magnet Moves a Stylus Laterally on Silicated Paper, Thus Registering Each Opening of the Accelerometer Contacts. The Paper Is Driven at Constant Speed by an Electric Motor. Paper Speeds of 0.1, 1.0 and 30.0 In. Per Sec. Can Be Obtained by Changing Gears

operate styluses that are in contact continuously with the paper. Interruption of the current through the magnets causes the styluses to move laterally on the paper and thus causes a record to be made of the accelerometer contact-opening. Additional recording elements are provided to enable the recording of speed, time and other functions it is desired to correlate with the accelerometer record.

CONTACT-ACCELEROMETER CHARACTERISTICS

The underlying theory of the contact accelerometer has been established definitely and substantiated experi-

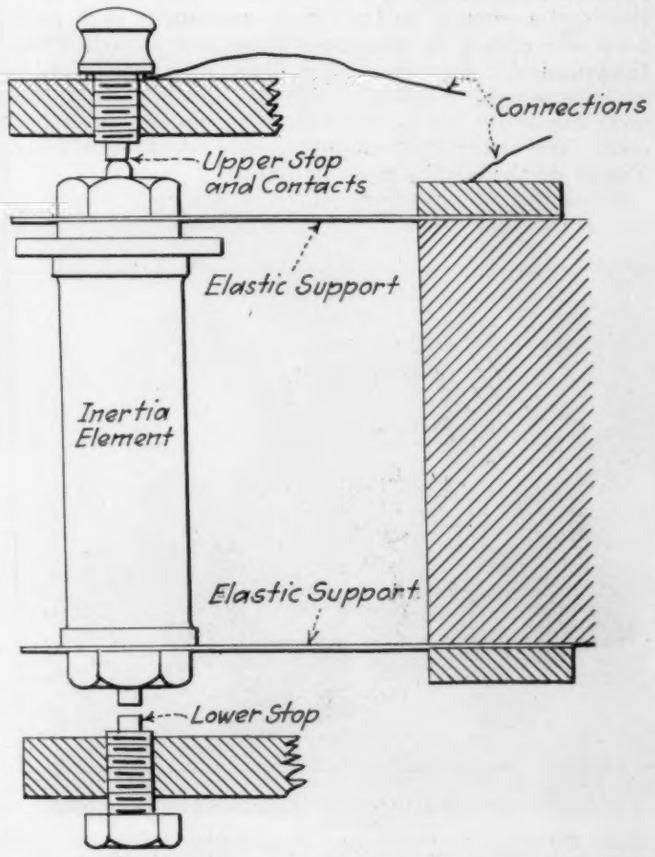


FIG. 6—SYSTEM FOR A CONTACT-ACCELEROMETER

A Weight, a Spring Mounting and a Pair of Contacts Constitute the Essentials of This Type of Accelerometer. The Manner of Mounting Can Be Varied Widely. Motion of the Weight Must Be Limited

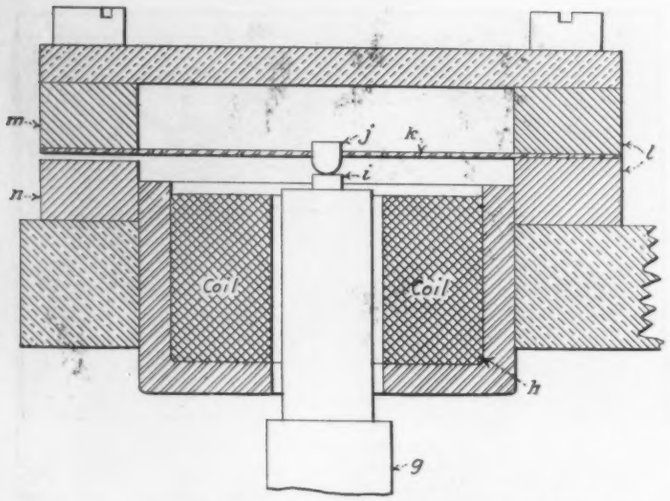


FIG. 7—CROSS-SECTION OF THE CONTACT-BREAKING DEVICE

The Upper End of the Accelerometer Weight *g* Extends through the Iron-Clad Solenoid *h* and Carries One of the Contacts *i*. The Other Contact *j* Is Carried on a Flexible Spring, *k*, Anchored at One End *l* and Free To Operate at the Other End between the Stops *m* *n*. When the Motion of the Weight Is Downward, the Solenoid Attracts the Spring until Its End Strikes *n* and Opens the Contact. This Demagnetizes the Coil and Permits the Spring *k* To Return to Its Normal Position against *m*; Hence, the Contacts Open Sharply and Remain Open Until the Weight Undergoes a Definite Upward Movement

mentally. The instrument consists of a mass or an inertia element supported by an elastic medium in such manner as to close or to open a pair of electrical contacts that serve also to restrain motion in one direction. Arrangements are made to limit motion in the opposite direction to a predetermined amount. The mounting of the inertia element on the elastic medium is such as to limit the motion to the axis of the two stops. These fundamental requirements are illustrated in Fig. 6, in which a weight, a spring mounting and a pair of contacts constitute the essentials of this type of accelerometer. The manner of mounting can be varied widely. Motion of the weight must be limited.

When the contacts were placed on the upper stops, it was found that the current through the contacts could be interrupted by a very minute displacement. By placing the contacts on the lower stops, it is necessary for the inertia element to travel through a distance equal to the clearance between the stops; hence, by varying the clearance between the stops, it is possible to eliminate all accelerations having displacements less than the amount of the clearance. This feature suggests numerous applications on such problems as engine, gear, propeller-shaft, and other high-frequency low-displacement vibrations. If it is desired to study the fundamental displacement only, as in the case of measuring axle-displacements, it becomes necessary to segregate all accelerations of a high-frequency nature. This has been accomplished in a practical manner by the means shown in Fig. 7, which shows a cross-section of the contact-breaking device. The upper end of the accelerometer weight *g* extends through the iron-clad solenoid *h* and carries one of the contacts *i*. The other contact *j* is carried on a flexible spring, *k*, anchored at one end *l* and free to operate at the other end between the stops *m* and *n*.

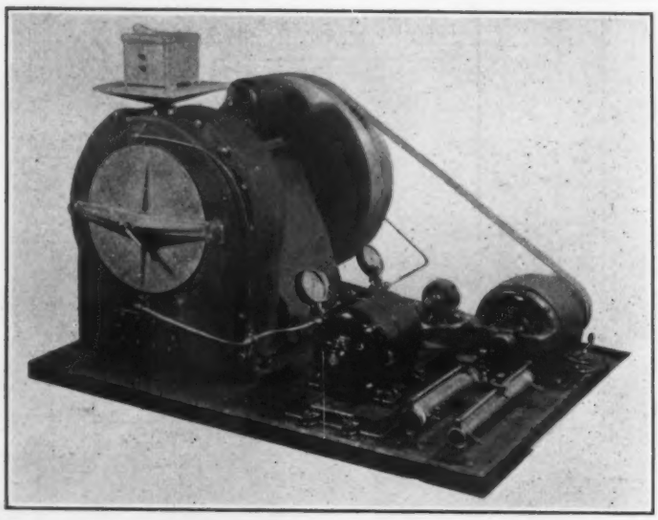


FIG. 8—SIMPLE-HARMONIC-MOTION ACCELEROMETER-CALIBRATION MACHINE

Rotary Motion Is Converted into Reciprocating Motion, Having Known Mathematical Characteristics, by a Scotch Crosshead. Independent High-Pressure Lubrication Is Provided to All Bearings. The Bearings Are All Plain and Are Arranged for Adjustment in Place. Heavy Flywheels and a Heavy Shaft Are Provided To Eliminate Angular Accelerations

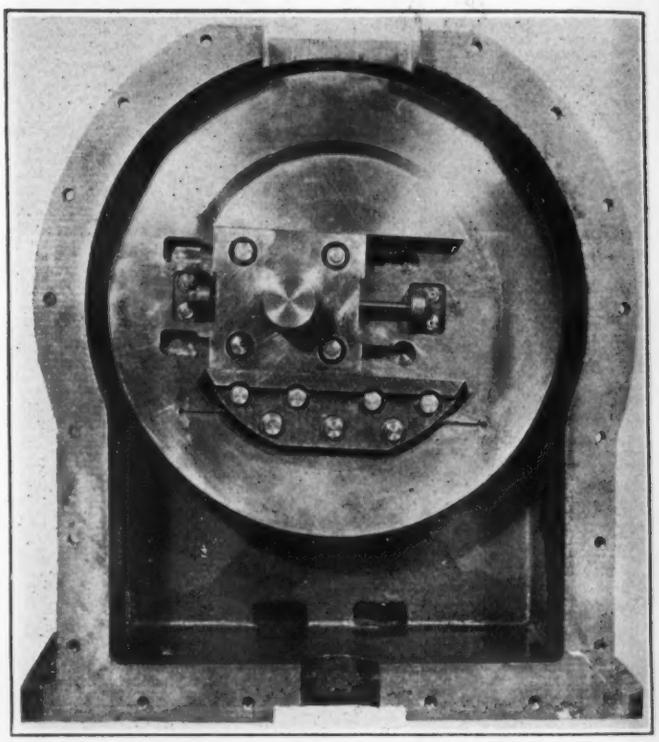


FIG. 9—CRANK-END OF THE CALIBRATION MACHINE

Arrangements Are Made To Adjust the Crank Throw from 0 to 2 In. No Effort Has Been Made To Balance the Crank. Instead, Sufficient Mass Has Been Provided in the Flywheels and Shafts To Render the Effect of the Unbalance Negligible

When the motion of the weight is downward, the solenoid attracts the spring until its end strikes *n* and opens the contact. This demagnetizes the coil and permits the spring *k* to return to its normal position against *m*; hence, the contacts open sharply and remain open until the weight undergoes a definite upward movement.

This contact construction not only serves to segregate the vibrations of small displacement, but it also causes the contacts to remain open for a definite time-interval, which is necessary if a mechanical recording or counting device is to be used.

ACCELEROMETER CALIBRATION-APPARATUS

A large amount of experience with space-time curves as a means for calibration has indicated this method to

have distinct limitations as to the attainable precision of interpretation and to be distinctly questionable from the point of view of accuracy. This also has been the experience of the majority of others[4] who have had occasion to differentiate space-time curves secured from vibrating mechanisms by chronographic means.

Some time ago[5], it was thought desirable to substitute simple-harmonic-motion for space-time curves as a means of calibrating and studying accelerometers. Experience with a filing machine as a means of securing simple harmonic-motion has confirmed this view and provided sufficient data to enable the design and construction of a more elaborate simple-harmonic-motion machine. In this machine, shown in Figs. 8, 9 and 10, elaborate precautions have been taken to secure a design and a construction that would provide a fundamentally satisfactory means of accelerometer calibration and inter-comparison. Rotary motion is converted into reciprocating motion, having known mathematical characteristics, by a Scotch crosshead. Independent high-pressure lubrication is provided to all bearings. The bearings are all plain and are arranged for adjustment in place. Heavy flywheels and a heavy shaft are provided to eliminate angular accelerations.

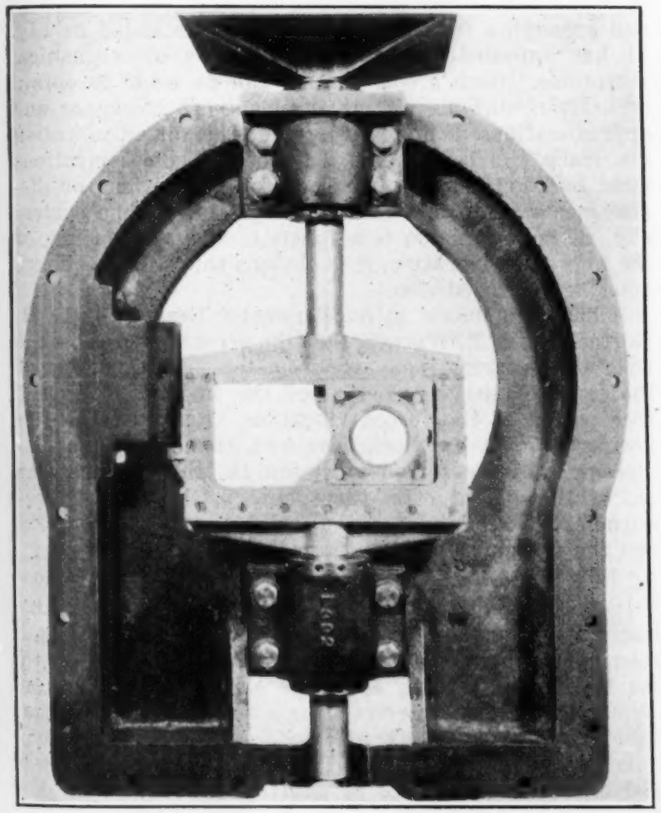


FIG. 10—CROSSHEAD OF THE CALIBRATION MACHINE
The Crankpin Rotates in a Bushing Having a Spherical Seat in the Crosshead Follower. Thus, Small Vibrations Due to Slight Misalignment Are Avoided. The Follower Is Guided in the Crosshead, and the Crosshead Is Prevented from Rotating by a Guide at the Left Side

The machine, as shown in Fig. 8, consists of a relatively heavy shaft mounted by adjustable tapered bronze-bushings in a heavy cast-iron case. A flywheel is mounted upon each end of the shaft, the total weight of the two flywheels being approximately 1000 lb. As

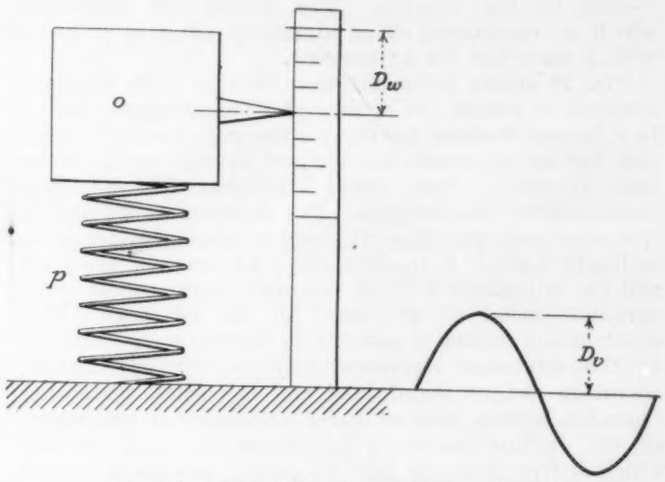


FIG. 11—SIMPLE WEIGHT-AND-SPRING SYSTEM
Corrections Must Be Applied To Secure Accurate Accelerations or Displacements with This System. As the Correction Is a Function of the Frequency of the Impressed Vibration, It Is Obvious That This Frequency Must Be Measured Also

indicated in Fig. 9, showing the calibration machine with its cover removed to expose the crank-end, arrangements are made to adjust the crank throw from 0 to 2 in. No effort has been made to balance the crank. Instead, sufficient mass has been provided in the flywheels and shafts to render the effect of unbalance negligible.

The adjustable crankpin is mounted upon one flywheel. This crankpin is guided by two tapered ways and is locked in place by the contraction of one of the tapered ways as well as by four bolts, the heads of which engage

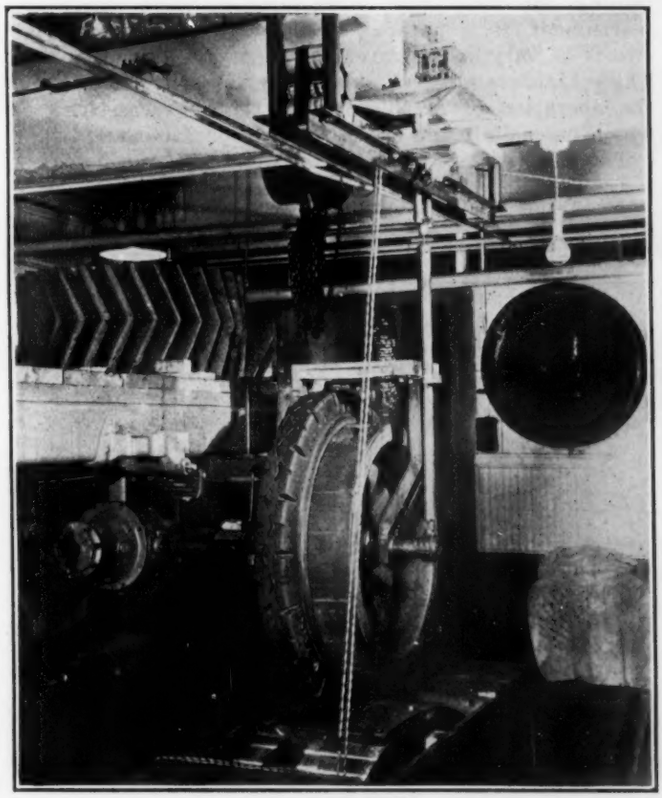


FIG. 12—INSTRUMENT INTER-COMPARISON APPARATUS
The Instruments Are All Mounted on the Same Platform, Which Is Guided on a Vertical Axle. The Motion of the Axle Is Transmitted to the Platform by a Connecting-Rod Having Flexible Ends Instead of Bearings. Provision Is Made for Mounting a Chronograph To Secure Space-Time Curves of the Platform

[4] See *The Electric Journal*, February, 1926, p. 71.
[5] See THE JOURNAL, July, 1925, p. 107.

T-slots in the flywheel. The Scotch-type crosshead, which is constructed of an aluminum alloy, is provided with a taper key for adjustment.

Fig. 10 shows the calibration machine with its cover removed to expose the crosshead. The crankpin rotates in a bronze bushing having a spherical external-surface that has an adjustable mating-part carried in the crosshead follower. Thus, small vibrations due to slight misalignment are avoided. The follower is guided in the crosshead, and the crosshead is prevented from rotating by a guide at the left side. All bearings are plain and are adjustable without removal. Independent pressure-lubrication is provided for all bearings. This construction makes it possible to eliminate lost motion, as the minimum clearance required for satisfactory operation can be maintained and the small remaining clearance is filled with oil under a pressure of 100 lb. per sq. in. In this manner a mechanism has been secured which is free from the high-frequency, low-displacement vibrations that are so common to all rotating and reciprocating mechanisms. It will be seen that this machine provides a means of securing, with a high degree of precision, simple harmonic-motion. Since the stroke and the number of revolutions per minute can be varied, the performance of accelerometers can be studied under a range of frequency and of acceleration conditions similar to those actually occurring in motor-vehicle axles and bodies in road service.

Accelerometer Calibration

It is desirable to determine the ability of any accelerometer to give accurate readings under the maximum range of the three variables—acceleration, displacement and frequency—which occur in actual use. After determining the frequency characteristics of a particular instrument, it is possible by substitution to study the effects of varying displacements upon the accelerometer. These features are particularly desirable in determining the operation of accelerometers, the characteristics of which necessitate the use of calibration factors.

The simplicity of mounting a weight on a coil spring and arranging for direct recording as indicated in Fig. 11 has appealed to many investigators of mechanical vibrations. Such a combination can be made to obtain accurate results only if measurements of frequency and approximations of displacements of the forced vibration are made simultaneously. In other words, corrections must be applied to secure accurate accelerations or displacements with this simple weight-and-spring system and, as the correction is a function of the frequency of the impressed vibration, it is obvious that this frequency must be measured also.

It has been shown, in Accelerometer Design[6], by F. H. Norton and E. P. Warner, that the error incurred in the weight-coil spring-type accelerometer is a function of the ratio of the free period of the instrument to the free period of the forced vibration. Recently, the following formula has been advanced[7] connecting the displacement of the forced vibration D_v, the displacement D_w of the weight o on the spring p, the natural frequencies of oscillation of the weight on the spring F_w and the frequencies of the forced vibration F_v.

$$D_w = D_v \left[(F_v/F_w)^2 \div (1 - [F_v/F_w]^2) \right] \qquad (1)$$

It is apparent that, when F_w approximates F_v, the instrument functions as a combination accelerometer and seismograph and that corrections must be applied to the instrument reading to secure either acceleration or displacement. This correction is a function of the ratio F_v/F_w and varies rapidly as F_v/F_w approaches 1; hence, it is necessary to measure F_v accurately if instruments of low frequencies are to be used in riding-qualities determinations. It is also apparent that, when $F_w > F_v$, the instrument reading D_w will be less than the impressed displacement D_v; hence, the necessity for approximating the impressed displacement is evident.

Separate cases occur in which a stop is applied to limit the motion to one-half of the cycle and in which measurements are made on the first half-cycle starting from a condition of rest; however, the same general reasoning applies. The contact accelerometer, due to its limited motion, is free from these corrections and measures acceleration directly.

Accelerometer Inter-Comparison

It was thought desirable to secure an inter-connection between the calibration of accelerometers on the simple-harmonic-motion machine and their performance under

[6] See National Advisory Committee for Aeronautics Report No. 100.

[7] See *The Electric Journal*, February, 1926, p. 73.

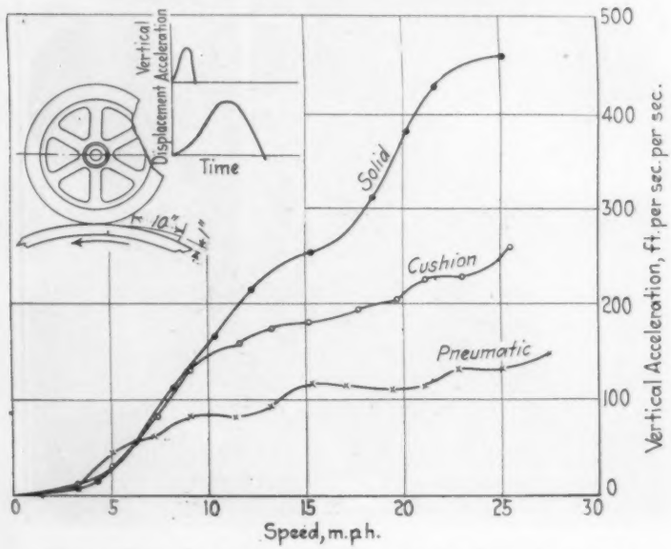


Fig. 13—Acceleration-Speed Curves of Solid, Cushion and Pneumatic Tires

These Values Will Vary Widely with Different Unsprung-Weight, Sprung-Weight and Spring-Rate; and with the Height and the Type of the Obstruction

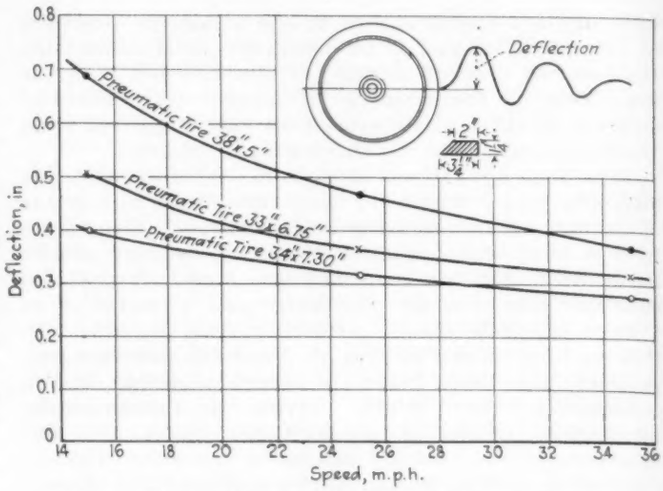


Fig. 14—Displacement-Speed Curves for Three Sizes of Pneumatic Tire

The Effect of the Tire Size Is Evident, Especially at the Lower Speeds

conditions similar to those occurring under actual road-service. An apparatus, shown in Fig. 12, was arranged so that the rear wheels of a truck chassis run on a large cast-iron drum and over an obstruction of any desired shape. The instruments were all mounted on the same platform, which was guided on a vertical axis. The motion of the axle was transmitted to the platform by a connecting-rod having flexible ends instead of bearings. Provision was made for mounting a chronograph to secure space-time curves of the platform.

A means of connecting the axle with the platform without lost motion, was secured, by the use of small-diameter short-length spring-steel flexible-members. The platform was made large enough to carry several accelerometers and provision was made for mounting the chronograph at the side of the platform so that the space-time curves of the motion of the platform could be made directly on the chronograph paper without any intervening linkages. This apparatus enables the studying not only of the performance of various accelerometers but also of the displacements and accelerations that occur with various tires, shapes of obstruction and different sprung and unsprung-loads.

Riding-Qualities Results

A large amount of detailed information has been secured, but it is too voluminous to present here. Efforts at present are being concentrated upon correlation of the various factors that enter into riding-qualities determination. As a whole this data indicates that these new instruments can be used to measure accurately the vibrations commonly encountered in various portions of the motor-car chassis. The portability, ease of manipulation and inherent characteristics of the contact-type accelerometer suggest such applications as:

(1) Investigation of the performance of seat cushions
(2) Studies of the performance of shock-absorbers and auxiliary spring devices
(3) Measurement of chassis-spring performance
(4) Determinations of the frequencies and the accelerations of recurrent vibrations caused by engine, transmission, propeller-shaft, rear axle, and wheels
(5) Locating and measuring maximum amplitude of vibration of body panels, floor-boards and other surfaces that are likely to vibrate in synchronism with some other part
(6) Investigation of tire performance under road-service conditions

Some typical results of tire performance investigations may be of interest. Fig. 13 shows the vertical accelerations of a truck axle caused by three different types of tire when striking an inclined-plane obstruction; that is, for solid, cushion and pneumatic tires. These values will vary widely with different unsprung-weight, sprung-weight and spring-rate, and with the height and the type of obstruction.

The vertical axle-displacements for three sizes of pneumatic tire are shown in Fig. 14. The effect of tire size is evident, especially at the lower speeds.

The possibilities of securing greater cushioning by radical cushion-tire constructions is indicated in Fig. 15, which shows displacement-speed curves for cushion and pneumatic tires. The effect of radical cushion-tire construction is apparent; however, other conflicting factors, such as mileage-life, traction and cost, limit the use of such radical designs.

Tires must withstand several conflicting conditions, and one of these conditions can be emphasized only at a

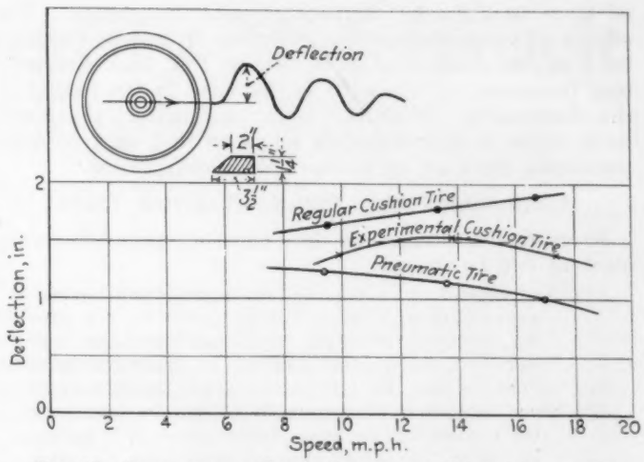


Fig. 15—Displacement-Speed Curves for Cushion and for Pneumatic Tires

The Effect of Radical Cushion-Tire Construction Is Apparent; However, Other Conflicting Factors, Such as Mileage-Life, Traction and Cost, Limit the Use of Such Radical Designs

sacrifice of some other one. Comparatively recent developments in cushion-tire construction have produced cushion tires having better riding-qualities than formerly. It must be remembered, however, that this additional tire-cushioning effect has been secured by at least a partial sacrifice of other desirable qualities. It appears that the logical truck-tire for a given service today may not be the correct tire for this service at some future date. This factor will be influenced by the cost of all factors entering into the cost of transportation. Possible improvements in road construction and in truck design will unquestionably influence the design.

Since it is a function of tires to minimize the effects of road roughness, it is desirable to know the reaction

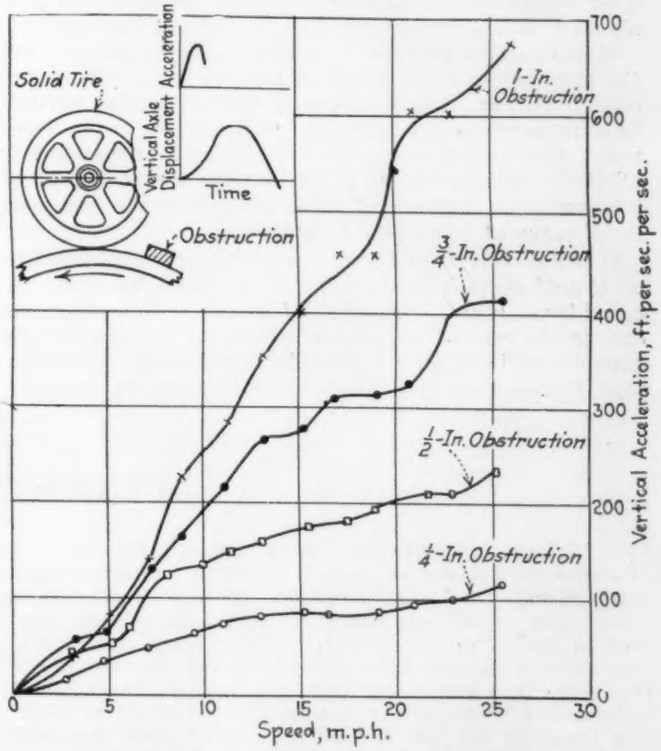


Fig. 16—Variation of Vertical Axle-Acceleration with Obstructions of Different Heights

Acceleration Increases Rapidly with an Increase in the Height of the Obstruction. With the ¼-In. Obstruction, the Maximum Value Is Approximately Equal to That Secured with Pneumatic Tires on an Inclined-Plane Obstruction

of tires to different degrees of road roughness. The effects of road obstructions, varying in height from ¼ to 1 in., on solid tires is shown in Fig. 16. Acceleration increases rapidly with an increase in the height of the obstruction. With the ¼-in. obstruction, the maximum value is approximately equal to that secured with pneumatic tires on an inclined-plane obstruction.

Conclusions from Riding-Qualities Tests

From results secured to date several outstanding conclusions can be drawn:

(1) Analyses of space-time curves taken from chronographic records of vibrating parts do not give accelerations accurate to within less than ±10 per cent, and in the majority of cases the inaccuracies may be, and probably are, much greater

(2) Since most accelerometers developed to date have been calibrated by space-time curves, it is probable that the accelerations measured by such instruments have been in error by an amount greater than ±10 per cent

(3) Dead-weight calibration, followed by check calibration on the simple harmonic-motion machine, indicates that accelerations can be measured with the contact-type instrument to within ±10 per cent on all values encountered in motor cars

(4) In the absence of definite information regarding the physical and mental effect of vibrations, it may be assumed that decreasing displacements and accelerations increase riding-qualities

Measurement of the various factors influencing riding-qualities emphasizes the need for reasonably accurate and convenient instruments and for an accepted criterion by which to judge riding-qualities. It is to be hoped that recent developments in instruments will provide sufficiently consistent data to permit correlation of the various factors entering into this complex subject and that study of the mental and the physical effects of vibrations will permit assigning numerical values to riding-qualities.

DESIGN, PRODUCTION AND APPLICATION OF THE HYPOID REAR-AXLE GEAR

(*Concluded from p.* 580)

spindle in accordance with the offset of the pinion with respect to the gear, and two angular adjustments of the cutter-spindle, about horizontal and vertical axes respectively. These adjustments are clearly seen in Fig. 7. In the testing and lapping operations, the machines must have the same offset of work-spindles as the pinion and gear shafts are to have in the final assembly. Fig. 8 shows a pair of hypoid-gears on the testing machine.

When cutting pinions, it is found advantageous to cut the upper side on one machine and the lower side on another. This saves time, as nearly all the machine settings have to be changed in going from the upper to the lower side. Pinion-cutters are then made with all outside or all inside cutting-edges, which permits a speeding-up of the machine. Cutters of 9-in. mean-diameter are used in all cases of hypoid-gears uptodate.

It will be seen from the foregoing that production costs of hypoid-gears will vary but little from the costs of spiral-bevel gears. The cost of blanks will be changed only in the case of the pinion, where the increase in the diameter will call for a slightly larger forging. If advantage is taken of the additional load-carrying capacity and gear-diameters are reduced, this will more than offset the additional cost of pinion blanks. For the pinions, the cutting cost will be slightly less on account of the practicability of using all inside and all outside blades on the cutters.

The use of a ring gear of smaller diameter and the location of the rear end of the propeller-shaft will have an important influence on chassis design. On account of the capacity of hypoid-gears for greater transmitted-load, a decrease of about 10 per cent in the ring-gear diameter can be made without increasing the unit-stresses. This makes possible a greater road-clearance. The lowered position of the driving pinion removes the chief obstacle to lowered floorboards at the rear end. Advantage can be taken of this to lower the entire body.

A very practical point of advantage for any present user of spiral-bevel gears who is considering the adoption of hypoid-gears is that the change can be made with but a slight change in manufacturing method or equipment. As has been pointed out, the finish-cutting of the pinion is the only major operation requiring machinery different from that used for spiral-bevel gears and pinions.

CHOOSING A JOB

THAT home influences often work against a boy's natural desire to become an expert mechanic is unfortunate. Many parents think that their sons should look for "white collar" jobs immediately after leaving school, without stopping to think what future a job that is taken temporarily may hold. This feeling is gradually giving way before the knowledge that any young man who receives fundamental training in a trade, even though he does not intend to follow that trade all his life, has gained a foundation that will stand him in good stead in his future life. The many successful men who started as apprentices prove it.

The biggest difference between the United States and other countries is our tremendous use of machinery to make the soil and our hands and our brains more productive. Machine tools and the men who operate them have made this possible.

The prospects for an apprentice are largely what he himself makes them. If he seriously wishes to work he can get an extremely thorough and practical training by applying himself closely to the training course. If he is ambitious he will be helped to the utmost by the men with whom he is working, and there is no reason why he cannot go to the top of the ladder if he will. Continual opportunities arise for practically trained men who are capable of making the new machinery that is constantly being developed.—Pratt and Whitney Co.

Vol. XVIII June, 1926 No. 6

The Problems of Intercity Motorcoach Operation

By ALEXANDER SHAPIRO[1]

METROPOLITAN SECTION PAPER

ABSTRACT

THE difference between success and failure in intercity motorcoach operation depends upon the way in which the operator and the drivers deal with a multiplicity of problems that combine to make the operator's job apparently a popular one. Beginning with the selection of the vehicles, the author discusses appearance and riding-qualities that appeal to patrons; the question of size and length of life with relation to frequency of service and replacement with improved models; the selection of honest, intelligent, resourceful, and courteous driver-personnel; choice of routes with reference to character of roads, potential patronage, existing transportation facilities, and connection with railroad lines; running schedules; lay-over stops for refreshment and relaxation; speed; dependability of service; the importance of the drivers' learning the habits of patrons and being on the watch for them; and extra service for special occasions.

Commercial travelers are mentioned as the mainstay of the interurban motorcoach line and a class of patrons to whom the wise operator caters as much as possible, particularly as regards dependability of service and inflexible adherence to running schedule. Under the term "comfort" the author deals with those finer phases of operation that affect the passenger's ease of mind rather than his physical comfort, such as furnishing information as to precisely where and when a coach can be met, clearly arranged and printed schedules and destination signs, knowledge that luggage is properly cared for, and freedom from the little but constant body noises that become annoying.

The operator and the driver must learn by experience to deal tactfully with a multitude of delicate problems concerning the carrying of bulky parcels by passengers, treatment of obnoxious persons, where to draw the color line, extent of advertising to be done in country newspapers, donation of services for charitable purposes, road courtesy, and, of course, the questions of vehicle maintenance, garage organization, and accounting.

Main emphasis throughout is placed upon the necessity of attracting and pleasing the traveling public, with the consciousness that a large percentage of patrons expect an intercity motorcoach to be as presentable in appearance and as comfortable, even luxurious, as a private passenger-car, and that if the service is not as convenient and dependable as they think it should be, they will ride in their own cars instead of patronizing the motorcoach line.

FIRST impressions may be deceiving but they have an influence, nevertheless. In purchasing motorcoach equipment, therefore, the operator is confronted with the problem of obtaining vehicles that not only will meet other requirements but that will "sell" themselves to the riding public. Patrons want to ride in the vehicle that resembles as nearly as possible their ideal of the private passenger-motorcar, a long, low machine whose outside lines and color appeal to the eye and whose inside finish gives that sense of luxury which they all desire to possess. The seats must be deep and roomy, the kind that produce a sigh of contentment. Ventilation and heating facilities should be good, the windows wide and so placed that an unobstructed view is afforded from practically every seat in the coach, and an adequate smoking-compartment and fully as adequate a luggage carrier must be provided. The motorcoach patron also likes to ride in a vehicle that is free from vibration and body noises and that has good riding-qualities and plenty of power.

While not all motorcoaches meet the specifications outlined, that is the type of vehicle the public prefers and that "sells" rides most easily. A vehicle such as has been indicated is its own best advertisement, and in intercity work, in which the distances covered are great, it will attract a certain volume of business of a trial nature.

The problem of the operator, when buying motorcoaches, is to obtain equipment that will not only meet the public desire but that can be operated and maintained economically. The operator knows that a low center of gravity tends to create an impression of safety in the public mind. He knows that a bright-color finish makes the coach easily visible and attracts attention. Such a finish, however, requires more painting maintenance and greater expense for washing. He seeks an engine that develops plenty of power and yet does not consume undue quantities of gasoline and oil. He looks for accessibility of parts so that replacement will be easy and for a make of coach for which replacement parts can be secured without delay.

The operator also wants an interior finish that looks luxurious and yet will not require too much maintenance. Such things as location of the gasoline tank with relation to the engine and accessibility for filling purposes, type of brakes, door control, driver's seat, double windows and windshield for cold-weather operation, location of spare tires, and type of water pump all concern him.

ARE VEHICLE SIZE AND LIFE BECOMING EXCESSIVE?

In selecting equipment the operator must consider the question of size. The tendency in the last 2 or 3 years has been toward larger and still larger motorcoaches. This has meant additional weight and therefore additional operating and maintenance costs. Large vehicles also mean reduced frequency of service, or at least failure to increase the frequency of trips in proportion to the increase in traffic. The question in many minds now is whether or not the manufacturers are making a mistake in building motorcoaches too large, and if it would not be better to operate smaller ones on a more frequent headway.

Another problem that confronts the operator is that of short versus long vehicle-life. Street-cars used to be purchased for a life of 20 years, and it was not unusual to run them for 10 years longer. The tendency recently by some motorcoach builders has been to produce vehicles on the same plan. This may be due to the demands of

[1] A.S.A.E.—Vice-president and general manager, Washington Rapid Transit Co., City of Washington.

some electric-railway operators who have been accustomed to equipment that has a long life, but is it not a mistake? If the public wants a vehicle that resembles a private passenger-car, should we not encourage the building of motorcoaches that will have a life of 4 or 5 years at most and give every opportunity for continued improvement of models rather than have a large investment tied up in high-priced equipment, the possession of which would prevent us from buying more uptodate equipment that would be more likely to attract increased traffic?

Drivers Must Be of High Type

The selection of driver personnel is another problem that the motorcoach operator faces. A modern intercity coach costs between $8,000 and $10,000. It travels long distances under practically no supervision, because the very nature of the operation makes supervision both difficult and expensive. The driver is in complete charge. He is entrusted not only with the vehicle but with the lives of as many as 30 persons. In case of difficulty, he must be capable of meeting a situation without aid. It is vitally important, therefore, that the men selected to drive intercity coaches should be of the highest caliber. They should be selected, not only for their driving ability and mechanical knowledge, but as well for their honesty, independence, disposition, intelligence, and initiative. It can be realized readily that anyone who possesses all of these qualities is of a very high type. Such men would be hard to obtain were it not for the fact that intercity motorcoach driving possesses a certain attraction, akin perhaps to the romance of the old stagecoach days, that draws a higher type of individual than would ordinarily be expected to become a motorcoach driver. When carefully selected and as carefully trained, well paid and given reasonably agreeable working-conditions, such men may make all the difference between profit and loss in the operation of an intercity line.

Importance of Careful Route Selection

The intercity operator has many other problems to consider, such as financial accounting, which is encountered in almost any business, and the selection of a route, which is essentially similar to the selection of a location for a store or factory. Every line of business endeavor has its peculiar difficulties, and the experienced motorcoach operator will know what are the weak and the strong points of his business. In selecting a route, for instance, he will study the sources of potential traffic, existing means of transportation and the condition of the highways between the places he plans to serve. According to the nature of the traffic, he will decide whether to take the most direct route or some roundabout route. The shortest may be over rough and dusty roads, while the roundabout route may pass through a settlement that will furnish additional business.

Too many operators are content merely to parallel existing transportation facilities instead of looking for opportunities to render equally profitable coach-touring service. I know of an instance of a motorcoach operator who started service by paralleling a railroad line for a distance of about 60 miles and barely made expenses. He looked around for other territory and finally decided that, by swinging his line away from the railroad, he would form a connecting link between two important railroad-centers that were not otherwise served. By adjusting his schedule so that the motorcoaches made train connections at both ends of the line, he was able to build up a business that he sold a few months later at a profit of $40,000. Many such opportunities await the man who studies his territory carefully before starting operation.

In working out schedules, the tendency is to duplicate existing service to a large extent, the only difference being a few more trips a day than a railroad is able to give without a larger volume of traffic. Much better financial results can be obtained in many cases by adjusting the motorcoach trips to supplement existing transportation service by making train connections at terminals so that riders can save time by using the motorcoach service as a connecting link.

Running Schedule Requires Careful Study

The scheduling of such an inter-connected service requires careful study of local conditions and a considerable readjustment until a schedule that is reasonably satisfactory is produced. When such a schedule has been established, however, it should be adhered to, and any changes that are made should be merely additions or subtractions. Months are required to accustom the public even to the existence of motorcoach service, and considerable advertising is necessary to familiarize patrons with the schedule on which the vehicles operate. It is important, therefore, that changes of schedule should be as few as possible and that if either additions or subtractions are made they should be made without radical changes in the regular schedule.

In arranging schedules, the question of speed is important. People want quick transportation, but too high speed is in violation of the law, is hard on the equipment and will keep away a certain class of patronage because of fear of accidents. There are some motorcoach drivers with whom I feel less anxiety when riding at 45 or 50 m.p.h. than when riding with some passenger-car drivers at 15 m.p.h. It takes some time, however, for the general public to recognize this difference in driving, and therefore it is important to keep the speed down.

Lay-Over Station Needed in Each Town

Intercity operation brings one sooner or later to the question of lay-overs. Experience has shown that persons who ride long distances should have an opportunity about every 2 hr. to exercise their muscles and obtain refreshments, hence the schedule should provide for lay-overs at places where there are adequate facilities. This raises the question of the selection of terminals.

In a number of Mid-Western and Western cities elaborate terminal buildings have been erected during the last few years to accommodate the constantly growing motorcoach operations. These usually are known as union motorcoach stations. In many cities a union motorcoach station is merely some well-advertised hotel or drug-store at which the vehicles of various lines stop to receive and discharge passengers, and where information regarding connections can be obtained and tickets purchased. Often the proprietors of these places receive no compensation for their services from the motorcoach operators, but the passengers buy refreshments, cigars and picture postal-cards. In other cases, however, the owner of the terminal exacts a cash payment as well as free transportation privileges for himself and his family.

The wise intercity motorcoach operator will select some sort of stopping place in every town through which his route passes, no matter how small the town may be. He will usually look for the gathering place of the town, some restaurant or drug-store or hotel where the unofficial "club" meets, and, if the owner has a good reputation, that is the logical place to stop. Care must be taken, however, to select a place that women will feel

it is safe to use; there are some places in small towns that a woman never will enter, although to all outward appearance it may seem to be the logical stopping-place. The terminals should be plainly marked and well advertised. If the proprietor is friendly to the motorcoach service, he can give the operator considerable additional business, but if he is unfriendly, he can injure the coach line severely.

Dependability of Service Essential

Three things that must be watched above all else in connection with operation are dependability of the service, its comfort and its economy. Dependability is of primary importance. Motorcoaches must be so maintained that they will seldom, if ever, break-down on the road. It should be regarded as a capital offense to run out of gasoline while on the road, to fail to have a spare tire or to be without tools with which to change one. A line that gains a reputation for dependability appeals particularly to the commercial traveler, who frequently plans on making very close connections and to whom every minute is worth money. Commercial travelers are the mainstay of the intercity line in many cases, and the wise operator caters to them as much as possible.

Failure to run on time, particularly running ahead of time, is another capital offense in intercity operation. There can be no excuse for it and none should be accepted.

Watching for passengers is of great importance. The driver of a motorcoach that stops to pick up and discharge passengers at any place along the road must be constantly on the lookout for prospective business. He must learn to remember that on Friday afternoon the school teacher at the crossroads is going home for the week-end, and that on Wednesday morning the farmer's wife, having finished her washing and ironing, may be going to the village for a matinee. He must remember the business-man who goes to town twice a week for nose treatment and the salesman who travels his route perhaps once a month. In that way he builds up a steady patronage that makes operation profitable.

Another point to be remembered in connection with dependability of service is the ability to furnish additional service on special occasions. If there is a definite "pick" of fruit every Saturday afternoon in summer, the motorcoach operator must be prepared to handle the pickers, even at a loss. He may have to hire private cars to help him, but, unless he does so, or if he fails to take care of his regular patrons, he will lose business on week-days, which he can ill afford to do.

What Comfort Means to Passengers

Comfort, or, as it is sometimes known, service, is a broad term. It may mean the broadcasting of information as to where and when motorcoaches operating between certain points can be boarded. It is a comfortable feeling to know when a motorcoach will be at a certain place on the route instead of having to inquire at several places in town, perhaps only to find that it has passed while you are inquiring. Comfort, to the passenger, means clearly printed and easily understood schedules and destination signs on the motorcoaches. It means a ride that is free from those little noises that become so annoying after a few hours; a ride that is free from vibration and from much variation in temperature. The passenger, to be at ease mentally, must feel that his luggage is being cared for; in too many cases the recollection of a perfect ride has been spoiled because, on reaching his destination, the passenger found that his luggage had been lost along the roadside, had been given to the wrong person or had been damaged by exposure to the weather.

To some passengers, comfort, or convenience, will mean permission to carry a spare tire for their car, or perhaps a young live pig. These are cases that have to be dealt with carefully and courteously; some persons will use their own cars if they are not given what they regard as service by the motorcoach line, and it requires considerable tact to make them realize that there are limits to service.

By experience the intercity motorcoach operator learns to watch for the thousand-and-one things that may make the difference between success and failure. He must deal with such questions as who should receive free transportation, to what extent should parcels and bundles of newspapers be carried, how much advertising should be placed in country papers, and how extensively should service be donated for charitable purposes. Other problems are the rate of speed that can be maintained safely; road courtesy to be shown; difficulties presented by snow, rain, and sleet; where to draw a color-line; and how to deal with riders who cause annoyance to other passengers or might do so if permitted to enter the motorcoach. There are also, of course, questions of maintenance, garage organization and many others that help to make the job of the intercity coach operator as popular as it seems to be.

WIRE GAGE PRACTICE IN THE UNITED STATES

As chairman of a sub-committee of the National Screw Thread Commission, in July, 1921, I began collecting information on the wire gage systems in use. At that time the intention was to propose a standardized system, to be known as the National Wire and Sheet Metal Standard. The data collected showed that 30 systems were in use to some degree. Four of them proved on investigation to be the same sizes under a different name. The names of the various gages arranged alphabetically and the nationality of each, as far as I have been able to determine in collaboration with several other men, is given in Table 1.

The total number of sizes of the gages listed is 1226 and of course it should not be necessary to have anything like this number to choose from to satisfy the industries, if we were not already tied up with some exacting requirement. Attention is also invited to the fact that the variation between some sizes is less than the tolerance of size that can be lived up to by manufacturers. Obviously the variation between sizes ought not to be less than the tolerance that can be maintained or the size could not be determined. If the variation in the smallest sizes were double the tolerance it would be as close as necessary, especially if we take into account the variation as made by two persons measuring the same piece. In my own experience I have not found that manufacturers can produce wire with a greater accuracy than the limits of 0.0003 in. and this is confined to small sizes, that is, under 0.0620 in. Some manufacturers claim to do so, but an inspection of their product does not confirm it.

Another important consideration in developing a standard was should the tolerance be both plus and minus the basic size, or one way, and if the latter, which way?

Judging from returns to a questionnaire that I sent out, the manufacturers of motors and generators and similar machines seem to buy from specifications that allow an equal plus and minus tolerance of the exact size called for. However, when I interviewed some of the electrical engineers they stated that this was because the wire manufacturers made the wire that way. When I asked how they calculated their resistance tolerance they all said they used a plus resistance tolerance, which would mean a minus tolerance on diameter and area. None of them inspected for size. Many users of steel wire, including twist drill manufacturers, specify a minus tolerance.—From a memorandum presented by E. C. Peck at a recent conference on wire and sheet metal gages.

TABLE 1—WIRE AND SHEET METAL GAGE SYSTEMS USED IN THE UNITED STATES

No.	Name	Nationality
1	Allhoff & Mueller Music Wire	German
2	American or Brown & Sharpe	American
3	American Screw & Wire Co. Music Wire[1]	American
4	American Steel & Wire Co.[2]	American
5	American Steel & Wire Co. Music Wire	American
6	Birmingham or Stubbs Iron Wire or Sheet	English
7	British Imperial Wire	English
8	W. N. Brunton Music Wire	English
9	Edison or Circular Mil	American
10	English Legal Standard	English
11	English Music Wire	English
12	Felten & Guilleaume Music Wire	Unknown
13	French Standard	French
14	Malin Iron Co. Cast Steel Music Wire	American
15	Metric Wire	French
16	Morse Twist Drill and Steel Wire	American
17	Old English	English
18	Poehlmann Music Wire[3]	German
19	G. W. Prentiss	American
20	Roebling[2]	American
21	Roebling Music Wire[4]	American
22	Standard Birmingham Sheet and Hoop	English
23	Stubbs Steel Wire	English
24	Trenton Iron Co.	American
25	Trenton Iron Co. Music Wire[4]	American
26	United States Standard for Sheets and Plates	American
27	Washburn & Moen[2]	American
28	Washburn & Moen Music Wire[1]	American
29	Webster & Housefall	Unknown
30	Wright Wire Co. Music Wire	American

[1] Gages 3 and 28 are similar.
[2] Gages 4, 20 and 27 are similar.
[3] This gage is similar to the first 32 sizes of gage 14.
[4] Gages 21 and 25 are similar.

HIGHWAY TRANSPORTATION

In the last 25 years the American public has increased the investment in its transportation plant from $10,500,000,000 to $50,000,000,000, and has increased its annual expenditure for transportation of property and persons from $1,500,000,000 to somewhere between $18,000,000,000 and $20,000,000,000. The increase in the annual transportation charge in the last 5 years has been due entirely to the increased expenditure on highway travel, which has more than doubled in that time, while the charge for railroad transportation has actually declined.

An inventory of the Nation's transportation system at the beginning of 1926 would have disclosed something like the tabulation in the next column.

Railroads and Equipment		Improved Highways and Motor Vehicles	
Miles	251,000		495,000
Locomotives	70,000		
Freight Cars	2,440,000	Motor Trucks	2,500,000
Passenger Cars	56,500	Automobiles	17,430,000
Rail Motor-Cars	500	Motorcoaches	70,000
Total Units	2,567,000		20,000,000
Investment	$25,000,000,000		$25,000,000,000
Annual Cost	$6,310,000,000		$12,125,000,000

The extensive ownership of automobiles and the large mileage of improved highways have resulted in loss of most of the local passenger travel of the railroads, except in the vicinity of the largest cities. The removal of local trains has left many communities with comparatively little railroad passenger service. The small volume of local travel in many such instances does not warrant more railroad service but does warrant the operation of motorcoaches at comparatively frequent intervals. The station to station and even shorter travel, which would not go by rail, makes up a considerable portion of the motorcoach traffic. The additional business that motorcoaches can expect will come largely from automobile users rather than from rail patrons.—From an address by Ralph Budd, president of the Great Northern Railway Co., at a meeting of the American Society of Civil Engineers.

Problems of Motor-Vehicle Administration by States

By Robbins B. Stoeckel[1]

Automotive Transportation Meeting Paper

FOLLOWING the presentation of this paper at the Automotive Transportation Meeting that was held at Philadelphia last November, the following written discussion was read. In accordance with our usual practice, a copy of the discussion as edited for publication was sent to the discusser for approval and to the author for the submission of any reply that he cared to make. The discussion as approved for publication is printed below.

For the convenience of the members a brief abstract of the paper precedes the discussion so that those who desire to gather some knowledge of the subjects covered without referring to the complete text and illustrations, as printed in the December, 1925, issue of THE JOURNAL, can do so with the minimum effort.

This completes publication of the discussion of the papers presented at the Automotive Transportation Meeting.

ABSTRACT

STANDARDIZATION of law and of equipment as it applies to the motor vehicle is discussed first, to the effect that traffic conditions call for standardization, that existing conditions make for different degrees in the whole problem, and that standardization must follow and be adapted to conditions since it cannot be attained in advance. With regard to standardization of manufacture and of equipment, the conclusions are that it is a part of uniformity of law and can take place only as an expression of the law or of a universal practice.

The loading and the overloading of passenger cars and of commercial motor-vehicles, including special considerations of loading from the standpoint of the capacity of the vehicle, are dwelt upon at length, motor-vehicle taxation is accorded similar treatment, and this portion of the paper is summarized by statements that loading is considered from the two viewpoints of total road-load and of loading to registered capacity, in relation to wear-and-tear on highways and to safety; that the "leeway" principle is a dangerous one; and that interstate traffic creates hardship under existing laws.

In commenting upon the motorcoach, a distinction is made between intrastate and interstate traffic and the considerations for each are detailed, the conclusions reached being that the intrastate vehicle is under adequate control by existing laws, but that any determination of desirability for its purposes should include a consideration of the traffic in which it will run and, further, that the interstate vehicle is not controlled, new State laws being needed to authorize motorcoaches, to route them and to manage them.

In most jurisdictions the measurement of what a proper speed is on the highway is determined by the test as to what is reasonable at a given place under the conditions that exist there. The principle is summarized in a statutory direction that one may proceed at a reasonable rate of speed. This subject is discussed in its several aspects, inclusive of "average rate" of speed and rates of speed that are slow enough to be dangerous, it being stated in conclusion that the best speed-law is that which prescribes a reasonable rate of speed, that vehicles must be capable of maintaining the average rate of reasonable speed on the highway and that the tendency of the situation is to evolve faster-traffic motor-vehicles of a large type.

As to restrictions regarding the size of vehicle, it is stated that, as necessity increases and the so-called "road rent" of a vehicle becomes higher, it will be natural that legislatures will restrict the size of large vehicles even more, the tendency probably being to throw the carrying of freight into smaller, faster moving vehicles as determined by the conditions of traffic itself. All the subject heads of the paper which deals with the pressing problems of administration and enforcement and that are now before the States are, properly, subjects for standardization. The problems are becoming more, rather than less pressing. The State viewpoint, taking into consideration the welfare of all the people who use the highways, will demand more and more management and restriction. Engineers and manufacturers will be influenced to produce a type of vehicle which is capable of average performance when considered in comparison with all the other motor vehicles.

THE DISCUSSION

G. H. Scragg[2]:—The paper prepared by Mr. Stoeckel is so complete and so comprehensive that it is practically impossible to enter into any discussion of it whatsoever. If State Administrators in general, over the last few years, had had Mr. Stoeckel's knowledge and had applied the broad facts that he does, as indicated in his paper, the industry in general would have considerably fewer problems to meet than it has today.

There is one exception, however, I should like to make, and that is on the subject of the Total Road Load. I do not think that the governing of the loads to be carried on a road should be limited by weight alone, that is, I do not think we can set a limit, say, for example, 26,000 lb. I am of the firm belief that such restrictions should be set on pressures on the road rather than on the gross load. Road damage is not done by static load alone. Speed, with its resultant impact, must be taken into consideration. It is obvious that a load of, say, 30,000 lb. on six wheels would do considerably less damage to the road because of lower pressures than would a load of 26,000 lb. on four wheels. Likewise, it is obvious that a 26,000-lb. load traveling at 25 m.p.h. will do considerably more damage than a 30,000-lb. load at 10 m.p.h. This, I believe, can be governed by basing the restrictions on pressure and by putting a limit on the speed at which solid-tire equipment may travel.

Wisconsin's scheme of rating loads seems to work out fairly well and seems to be a sane method of handling the question of roads that are built to handle light traffic only.

With all the discussion that there is on the intrastate motorcoach and its control, I thoroughly concur with Mr. Stoeckel's viewpoint. There is too much talk

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[2] M.S.A.E.—Executive, motorbus department, International Motor Co., New York City.

of restricting, or governing, this class of transportation. If the State police powers are great enough to handle the routing of the motorcoach when it interferes with other traffic, I believe that the interest of the public will be better served than by an attempt to set up a body governing this class of transportation.

Referring to my statement of some of the problems that the industry has had to carry because of hasty legislation, I would like to bring to your attention some of the laws that have recently been passed restricting the use of the motorcoach. Incidentally, if these laws continue, there need be no question of interstate control, because with such laws multiplied, it will be illegal for the motorcoach of one State to operate in a State adjacent to its home. I believe every effort should be made to restrict the passing of such laws, because they are unsound economically, and such control can come only after the laws in the States themselves have been standardized. For instance, we have one State claiming that motorcoach doors must open outwardly so that, in the event of panic, passengers can force their way out. A neighboring State says that doors must open inwardly, in order that persons may be prevented from falling out.

We have the law that says that colored markers cannot be used as destination lights. This restriction means slower schedules, because at night it is necessary for patrons of the line practically to stop the motorcoach, to find out whether it is the one they want. Other States say that such destination lights must be employed.

We have one State demanding that the emergency door be in the rear-center of the motorcoach, and another State demanding that it shall be on the left.

With the laws in effect concerning lighting, it is illegal for a man in an automobile or a motorcoach to drive from New York City to San Francisco. Yet it is done.

The width restrictions in some of our Southern States make impossible the use of the four-passenger-width seats, which has almost come to be considered standard and, because of the load it allows in the motorcoach, it is the most economical.

In another State we have the body length restricted; and this restriction is 6 ft. less than the length allowed for a truck. Turning-radius should have been the basis of this law, as its object was to prevent motorcoaches in congested areas from blocking the traffic when making turns. One State law has gone so far as to specify the actual dimensions of the steel to be used in the chassis frame, without, however, saying what kind of steel is to be used. It is obvious to everyone that a poor-grade steel of the sizes specified would have a lower factor of safety than a steel of smaller dimensions but of higher quality.

The use of dual tires is so heavily penalized by excessive taxes that it is necessary to use single tires. Tax pressure also is used in one State to prohibit the use of a sturdy, well-built motorcoach and forces upon the operator a lighter vehicle, no matter what his own judgment in the case may be.

Then, too, we have the case of the State that governs the number of standees. This necessitates a greater number of motorcoaches on the street to carry a given number of persons, increasing the ratio of vehicles needed in peak and off-peak periods, and thereby encourages the operator to give inadequate service.

No attempt has ever been made to belittle the work of the public utilities in transportation, particularly in urban street-car service, without running the word "strap-hangers" in capitals; yet one State demands that motorcoach operators furnish straps for standees, although it is generally conceded that the sanitary horizontal bar, because of the low roof, best serves the purpose for which it was designed.

These are just a few high-spots on some of the things that have been written into laws for the governing of motorcoaches. They all have a tendency to increase the cost of production. It is conceivable that each of the 48 States could believe that it had a better method of governing its motorcoach operators than the other 47 and, as a result, the manufacturer would be compelled to build 48 models of chassis and body to take care of the different States. This would prohibit production, as we understand it today, and, as a natural result, the building of bodies in small quantities would increase their cost and their price. This price ultimately would have to be passed on to the rider.

Therefore, let us as an engineering society be very careful before we set-up specifications or concur with the lawmakers of States on the specifications that they would like to set up to take care of what they consider peculiar conditions within their States.

Let us not rush recommendations for standards until we are sure that development will not be retarded. If we go too fast, we will find that our recommendations are ignored. Recently we passed a resolution to use the word "coach" in preference to "bus." Here today, at our own meeting, since my arrival the word bus has been used 114 times and the word coach 7 times. This would indicate that general usage is stronger than our recommendations.

WHY APPRENTICESHIP PAYS

THAT apprenticeship training is a good investment is proved by the experience of such firms as the Brown & Sharpe Mfg. Co., R. R. Donnelley & Co., the Santa Fe Railway, and others that have had such schools for a long period of time.

The value of apprentice education to a business is to be seen in better quality of work, larger output, loyalty of spirit, reductions in the quantity of spoiled work, lower labor turnover, and like advantages. It is not always measurable in terms of dollars, though some firms have succeeded in measuring certain items.

The Santa Fe Railway, for example, estimates that about 90 per cent of its apprentices remain with the company. Figures of the secretary of the Milwaukee Metal Trades Association show that, whereas the average labor turnover for 1923 was 190 per cent and the cost, $4,250 for every 100 men; the turnover among apprentices was almost nil; therefore, 10 apprentices for every 100 men means a saving of $425 for the year. The experience of the Westinghouse Electric & Mfg. Co. indicates that at least 40 per cent of its graduate apprentices eventually become members of the company's supervisory force, and that the labor turnover for graduate apprentices in the year 1924 was only 3 per cent.—Dorothy Sells in *Industrial Management.*

Influence of Temperature, Fuel and Oil on Carbon Deposition

By S. P. Marley[1], C. J. Livingstone[2] and W. A. Gruse[3]

Semi-Annual Meeting Paper *Illustrated with* Photographs and Charts

ABSTRACT

HIGH operating-temperature, the use of the more volatile fuels and a lean air-fuel mixture and the use of lubricating oils of relatively high volatility which contain little carbon-residue all tend to reduce the deposition of carbon in an internal-combustion engine, as indicated by the experimental study reported in this paper.

Believing that heat, fuel and oil are the most important factors influencing carbon formation and deposition, the experimenters adopted the method controlling closely the other conditions of operation of a specially designed single-cylinder test-engine and varying the operating temperature and the fuel and oil, allowing the carbon deposit to build up in the normal way during the test periods of 15 and 36-hr.

The test engine and control apparatus and the test procedure are described. Room temperature was held constant throughout each run, oil and cylinder-head temperatures were controlled to within 6 deg. fahr., the air-intake temperature was kept constant within 1 deg. fahr., the engine-speed was measured in revolutions per minute, and the rate of fuel intake was held constant at a constant throttle-setting, giving a uniform air-fuel ratio as determined by exhaust-gas analysis. As confirmation of the accuracy of control, it was observed that the power output was constant within an average of 1 per cent.

After conclusion of a run, the engine was taken-down and the carbon deposits from the piston and from the cylinder-head were recovered separately and weighed. Seven different liquid fuels and six different lubricating oils were used in the various runs.

From data obtained it appears that the carbon values are fairly constant until the head temperature rises somewhat above 400 deg. fahr., after which there is a drop in them as the heat is increased. Deposits formed at the lower temperatures are much more asphaltic, softer and less adherent than those formed at the higher temperatures. With evaporative or steam-cooling, the head temperature was as low as or lower than the lowest with water-cooling, and carbon deposition was almost at the same rate as with water-cooling at the same temperature.

No marked change in quantity of carbon is noted with different fuels through the series of commercial gasolines, but excessively high carbon-values were obtained with the heavy cleaners' naphtha and kerosene, due, it is believed, to poor carburetion and incomplete oxidation and to asphaltization of sprayed liquid. Benzol blend gave slightly more deposit than motor fuel, but the deposit was softer and more soot-like. Natural gas gave only 5 per cent less deposit than commercial gasoline, which is interpreted to mean that in a 12-to-1 mixture a good average grade of gasoline plays a very small part in the deposition of carbon.

It runs simulating ordinary cool-weather operation of automobiles, with a 10-to-1 ratio of air and ordinary automobile gasoline, lubricating oils distilled from Pennsylvania and Mid-Continent crudes gave considerably higher carbon-deposits than oils derived from Gulf Coastal crudes. The different oils suffered dilution in the crankcase to the same extent with the same fuel and operating conditions.

Under conditions simulating summer operation, with a mixture-ratio of 12 to 1, the carbon deposit with Gulf Coastal oil was only half of that with Pennsylvania oil, while that from Mid-Continent oil was midway between. Extraction figures from the Gulf oils show that they contain less oily matter than the less-volatile oils. Carbon from them was, in general, dry, powdery and friable, while that from Pennsylvania oils was very hard and adherent over the hotter areas and sticky and asphaltic over the cooler areas of the combustion-chamber. Popular belief that there is a connection between so-called heat-resisting properties of an oil and its desirability as a lubricant is probably erroneous; the oil that will leave the least residue upon evaporation from the metal surfaces will give the least trouble from carbon deposition.

Suggestions offered for avoidance of carbon trouble are that (*a*) oil consumption be kept at the minimum consistent with a fair margin of safety, (*b*) excessive and irregular cooling be avoided, (*c*) the fuel-air mixture be kept on the lean side of smooth operation, and (*d*) the oil that is the more volatile among those of the same viscosity probably will be the more satisfactory.

THIS paper presents an experimental study of the three factors believed to be important in the formation of carbonaceous deposits in internal-combustion engines. The method of holding all operating conditions constant except the one under study has been adopted. Thus, head temperature, fuel, and lubricant were varied in turn, and the results observed. Previous studies on carbon deposits have been published by Orelup and Lee[4] and by Brooks[5]. These investigators, to accelerate the formation of deposits, adopted the device of mixing a small percentage of lubricating oil with the fuel. It may be noted that they encountered great difficulty in duplicating results. We have adopted the other alternative of controlling very closely the operation of a specially designed, single-cylinder test-engine and allowing the deposits to build-up in the normal way. It was believed that this procedure would conform more closely than the former to what happens in ordinary automobile use. This belief is justified by the fact that we were able to duplicate results as closely as could be desired. We wish to acknowledge the valuable suggestions of Dr. W. F. Faragher, assistant director of the Mellon Institute, during the planning of this investigation.

Test Apparatus and Procedure

The experimental apparatus, shown in Figs. 1 and 2, was evolved by successive modifications of an 850-watt

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[4] See *Industrial and Engineering Chemistry*, July, 1925, p. 731.

[5] See The Journal, January, 1926, p. 48.

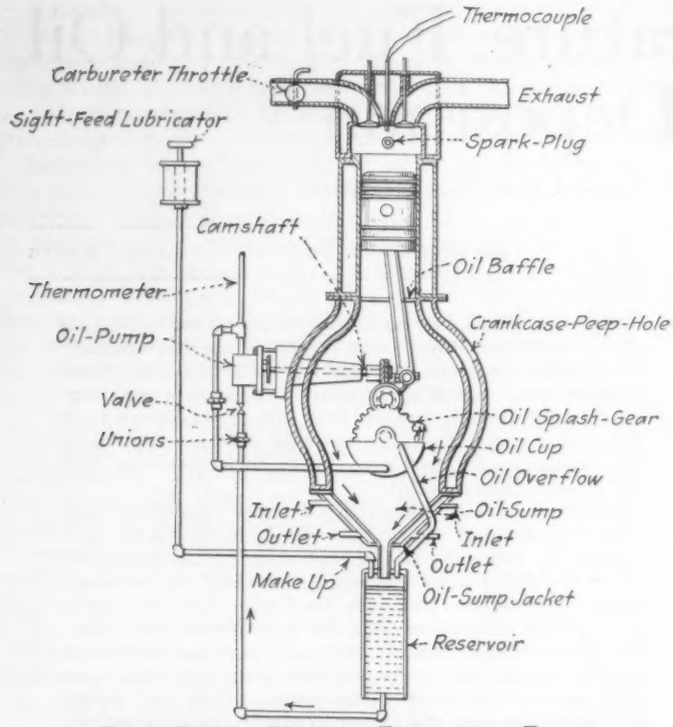

FIG. 1—VERTICAL SECTION OF EXPERIMENTAL ENGINE

The Air-Cooled Head of an 850-Watt Delco Generating-Plant Engine Was Replaced by a Water-Cooled Head and the Cylinder, Crankcase and Oil Sump Were Similarly Water-Jacketed. Head Temperatures Were Taken by a Thermocouple in a Well. Oil Was Supplied from a Graduated-Glass Reservoir at the Bottom to a Gear-Pump and Measured with a Sight-Feed Lubricator. Fuel-Flow from a Small Carbureter Was Controlled by Timing the Flow of a Measured Volume from a Pipette. Constant Air-Temperature Was Maintained by an Exhaust-Heated Stove. Cooling-Coils Kept the Circulating Water at Constant Temperature. A Counter Registered the Crankshaft Revolutions

Delco generating plant. The air-cooled head was replaced by a suitably designed water-cooled head carrying a thermocouple-well projecting into the combustion-chamber about ⅜ in. The wall thickness at the bottom of this well was 1/16 in., and the temperatures observed bore a constant relation to the temperatures of the inner wall of the combustion-chamber.

The original air-cooled cylinder was used interchangeably with a water-cooled cylinder, and a water-jacketed sump replaced the bottom of the crankcase. A system for circulating a small charge of oil was installed, this substitution making possible the observation of very small variations in oil consumption. A gear oil-pump, mounted on the camshaft, supplied oil from a graduated glass reservoir to a small cup fitting under the lubricating gear, which delivered the oil to the crankshaft and other moving parts. Overflow and drainage oil returned to the glass reservoir for recirculation, and make-up oil was added there from a sight-feed lubricator.

The engine was supplied with fuel through a small carbureter, the rate of supplying fuel being controlled by timing the flow of a measured volume from a pipette. The air entering the carbureter was maintained at a definite temperature by an exhaust-heated stove. Load on the generator, and hence on the engine, was controlled by resistances. The water supplied to the different parts of the engine was kept at the required temperature by cooling-coils. The speed of the engine and the total number of revolutions were observed by a counter driven from the flywheel end of the crankshaft. A covered peep-hole afforded visibility in the crankcase.

In preparation for a run, a 1-liter (0.947-qt.) charge of oil was introduced into the glass reservoir, the valves were ground, the clearances set, and the spark-timing fixed. The sight-feed lubricator was charged with 200 cc. (12.204 cu. in.) of oil. In starting a run, the apparatus was brought to selected conditions as quickly as possible to avoid dilution of the oil. To make its effect on other conditions uniform, room-temperature was kept constant throughout each run. The average oil-temperature and cylinder-head temperature were controlled to within 6 deg. fahr. of the selected values. The speed of the engine, as measured in revolutions per minute, and the rate of fuel intake were kept constant at constant throttle-setting, giving a uniform air-fuel ratio, as determined by exhaust-gas analysis. Intake-air temperature was kept constant to within 1 deg. fahr. In confirmation of the accuracy of control attained, it was observed that the power output was constant to within an average of 1 per cent.

After the completion of a run, the oil was allowed to drain from the system, the engine was dismantled, and the carbon deposits recovered. A pan, fitting down over the cylinder, was used to prevent the loss of carbon deposits on the piston, the piston and head deposits being kept separate.

FUELS AND OILS USED IN TEST RUNS

Seven different liquid fuels were used in the test runs: casinghead gasoline, special gasoline, a light-gravity blend, motor fuel, a benzol blend, cleaners' naphtha, and kerosene. The gravity and distillation characteristics of these fuels are given in Table 1.

Six different lubricating oils were used, two each from

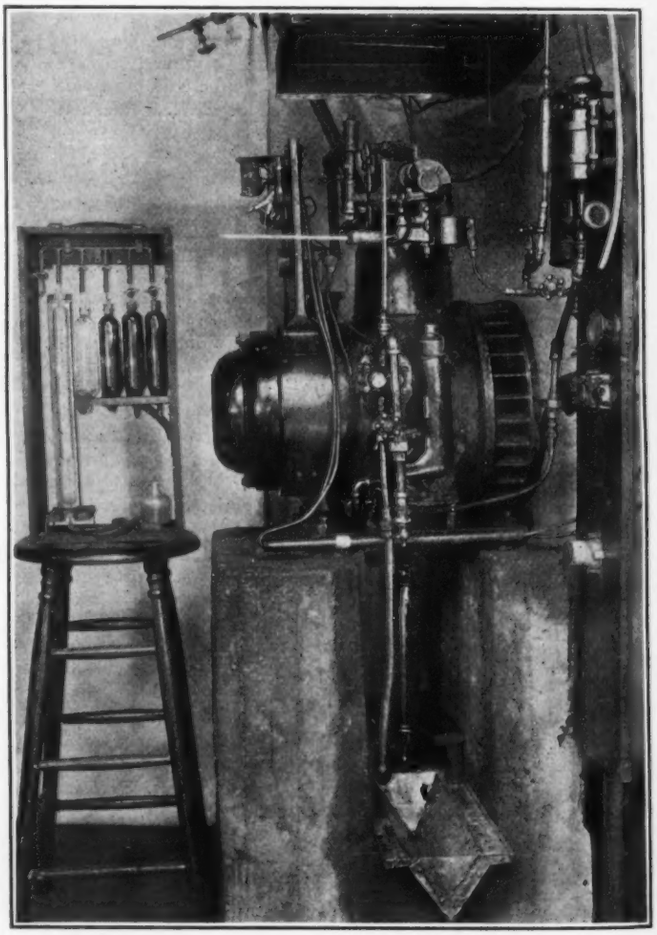

FIG. 2—TEST APPARATUS ASSEMBLED

TABLE 1—DISTILLATION DATA OF TEST FUELS USED

Fuels	Casinghead Gasoline	Special Gasoline	Light-Gravity Blend	Motor Gasoline	Benzol Blend	Cleaners' Naphtha	Kerosene
Gravity, deg.[6]	80.0	58.9	71.0	60.4	42.3	54.9	39.6
Over Point, deg. fahr.	82	124	86	100	140	244	260
Dry Point, deg. fahr.	270	434	418	435	423	419	482
Deg. Fahr.							
221, per cent	85.0	24.5	56.5	32.0	51.5	....	....
284, per cent	....	51.3	76.0	53.8	72.0	16.7	3.0
392, per cent	....	90.4	90.0	90.3	95.0	94.0	66.0
Per Cent							
10, deg. fahr.	94	182	106	145	171	276	326
20, deg. fahr.	102	210	121	180	188	287	342
30, deg. fahr.	112	234	143	214	195	298	350
40, deg. fahr.	122	258	166	243	208	308	360
50, deg. fahr.	134	281	198	273	218	318	379
60, deg. fahr.	150	304	236	300	241	328	384
70, deg. fahr.	171	330	270	329	280	335	397
80, deg. fahr.	199	354	326	356	324	356	412
90, deg. fahr.	242	391	392	391	375	376	435
Recovery, per cent	93.0	96.5	92.5	96.0	97.0	98.0	...

Natural gas-density, 0.67; atmospheric B.t.u., 1120; composition—methane, 86 per cent; ethane, 12 per cent; carbon dioxide, 0.1 per cent; hydrogen, 1.4 per cent; oxygen, 0.1 per cent.

[6] American Petroleum Institute at 60 deg. fahr.

Pennsylvania, Mid-Continent and Gulf Coastal crude petroleum. Their gravity, viscosity, flash and fire tests, and their Conradson carbon-residue are given in Table 2.

To indicate the degree of accuracy attained in duplicating results, three pairs of runs are given in Table 3 to show the range of duplication.

In presenting the results of all the experiments reported, attention has been directed to the carbon deposited in the cylinder-head of the engine. It was noted that the carbon deposited on the piston was always contaminated by a considerable proportion of liquid oil. Two alternatives were possible: to report all carbon, corrected for oil content, or to report only the carbon on the head surfaces. It was found that the two methods gave comparable results. This is true in general because in these experiments the weight of deposit on the piston was relatively small, and also because, in any series of experiments in which conditions did not differ too widely, the weight of the piston deposit was approximately the same. In the experiments involving variations in temperature, the procedure adopted is logical because it is the temperature of the head surfaces, and not of the piston, which is varied. For the variations in fuel also, the deposits on the head surfaces probably would be more affected by such changes than would the piston deposit.

For deposits obtained in experiments in which the lubricating oil was varied, both ways of presenting the data bring out the same facts. One disadvantage here, however, for the use of head carbon figures is that with some lubricating oils the total deposit is very small. When a fairly constant figure for piston deposit is subtracted, the carbon value, in grams of carbon per liter of oil, is perhaps unduly low. In the lubricating-oil series, therefore, both the head carbon figures and the carbon value for total carbon, corrected for oil and ash, are given.

These experiments were made in a substantially dust-free laboratory, which kept the ash content of the deposits down to an average of less than 5 per cent. The ash content of all deposits was determined, but the figures are not sufficiently significant to be used in this report.

TABLE 3—COMPARISON OF RESULTS OF TEST RUNS UNDER DUPLICATED CONDITIONS

Fuel Used	Motor Gasoline		Special Gasoline		Natural Gas	
Air-Fuel Ratio	12 to 1		10 to 1		12 to 1 [a]	
Duration of Run, hr.	15		36		15	
Head Temperature, deg. fahr.	437		365		400	
Room Temperature, deg. fahr.	78		73		73	
Oil Temperature, deg. fahr.	100		86		...	
Dilution, per cent	Negligible		9		....	
Speed, r.p.m.	....		1,140		1,090	
Power Developed, watts	620		700		700	
Run No.	C-12	C-13	DE-3	DE4	C-61	C-62
Oil Consumption, cc.	165	155	280	290	190	200
Total Carbon Deposit per Liter of Oil, grams	1.941	1.845	3.158	3.470	1.810	1.901

[a] Determined by carbon-dioxide content in the exhaust gas.

Effect of Variations in Head Temperature

The data for these experiments are presented in Table 4, from which it may be noted that the carbon deposits and the carbon values drop off with increasing temperatures. At the lowest operating-temperatures slightly higher carbon values are reached than those obtained over the range of increasing temperatures next following. From the data it appears that carbon values are more or less constant until head temperatures somewhat above 400 deg. fahr. are reached. At still higher tem-

TABLE 2—DATA OF THE LUBRICATING OILS USED

No.	Source	Gravity at 60 Deg. Fahr. Specific Gravity	Gravity at 60 Deg. Fahr. Degrees[7]	Viscosity, Saybolt Sec. at 100 Deg. Fahr.	Viscosity, Saybolt Sec. at 210 Deg. Fahr.	Flash Point by Open Cup Method, Deg. Fahr.	Fire Point by Open Cup Method, Deg. Fahr.	Carbon Residue Conradson Test, Per Cent
1	Pennsylvania	0.8753	30.2	365	56	440	490	0.51
2	Mid-Continent Blend	0.9034	25.2	357	54	412	474	0.64
3	Gulf Coastal	0.9370	19.5	358	49	358	408	0.12
4	Pennsylvania Blend	0.8745	30.4	307	53	424	476	0.44
5	Mid-Continent Distilled	0.9024	25.3	302	51	422	476	0.26
6	Gulf Coastal	0.9320	20.3	300	47	350	400	0.03

[7] American Petroleum Institute.

TABLE 4—CONDITIONS OF TESTS AND RESULTS OBTAINED

Head-Temperature, Deg. Fahr.	Oil Consumption, Cc.	Carbon on Head, Grams	Head Carbon Value per Liter of Oil, Grams
	Water-Cooling		
338	300	2.663	8.9
340	260	2.417	9.3
368	280	2.274	8.1
400	260	2.178	8.3
435	190	1.414	7.4
455	230	1.371	6.0
665	320	0.951	3.0[b]
	Evaporative-Cooling		
336	250	2.068	8.0
338	400	3.447	8.6
338	400	3.660	9.2[c]

Air-fuel ratio, 12 to 1. Duration, 15 hr. Oil temperature, 99 deg. fahr. Room temperature, 73 deg. fahr. Speed, 1090 r.p.m. Power, 700 watts. One lubricating oil. Motor gasoline.

[b] Air-cooled.

[c] This run made with the benzol blend.

peratures there is a drop in carbon values which is believed to be real.

As might be anticipated, the deposits formed at the lower operating-temperatures were much more asphaltic, softer and less adherent than those formed at higher temperatures.

As a matter of current interest, the figures in Table 4 may be compared with results obtained with the same

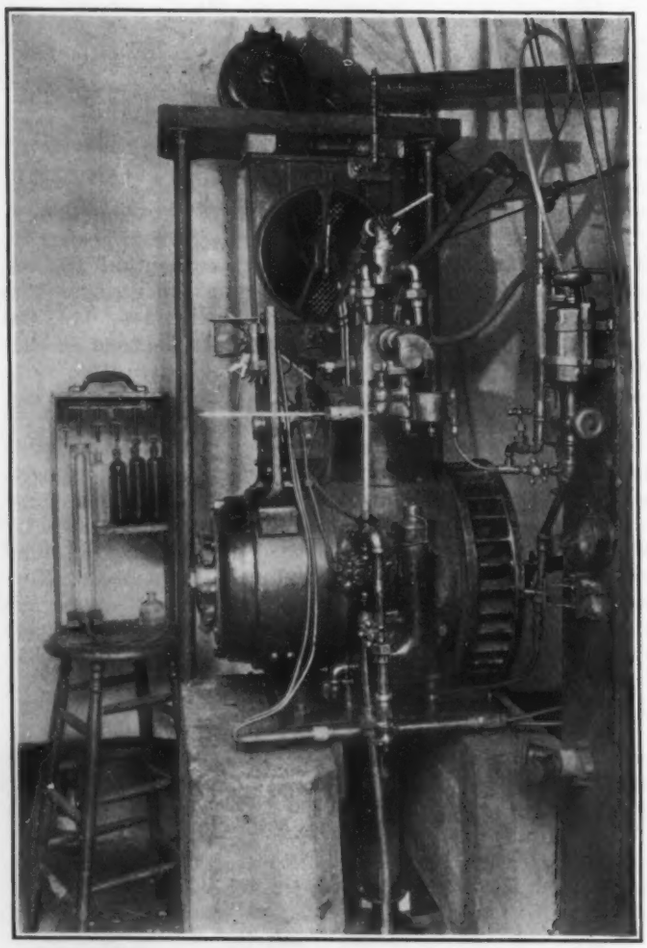

FIG. 3—TEST ENGINE PROVIDED WITH ATTACHMENTS FOR EVAPORATIVE-COOLING

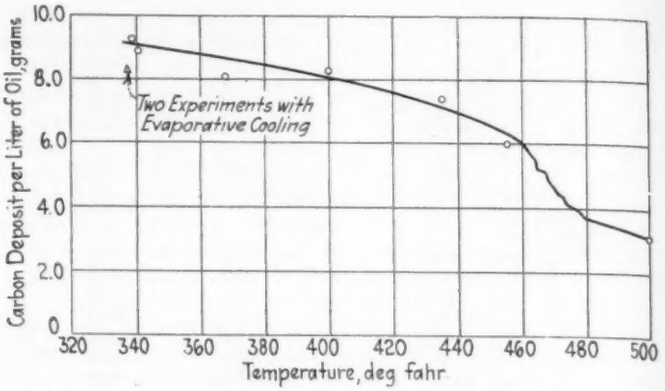

FIG. 4—CURVE OF CARBON VALUES PLOTTED AGAINST HEAD TEMPERATURES

Note Drop in Grams of Deposit per Liter of Oil Consumed as the Cylinder-Head Temperature Was Increased. Two Experiments with Evaporative-Cooling Gave Low Operating-Temperature and Approximately Corresponding Carbon Value, as Indicated by the Triangle

engine provided with attachments for evaporative-cooling, as shown in Fig. 3. These results, together with those of the experiments with water-cooling, have been used for the curve in Fig. 4, carbon values being plotted against head temperatures. It will be noted that, in the apparatus used, the head temperature for evaporative-cooling established itself well down in the range of temperatures obtained with water-cooling. Furthermore, the carbon values obtained are approximately the same as those found at the corresponding temperatures with water-cooling. It may thus be said that the efficiency of evaporative-cooling in our apparatus is confirmed by the moderately high carbon values obtained in these experiments.

RESULTS OBTAINED FROM DIFFERENT FUELS

In Table 5 are given figures for a series of runs that were duplicates in every way except for the fuel used. The latter varied from natural gas through a series of commercial gasolines to heavy naphtha and kerosene. No marked change in weight of deposit is to be noted until the figures for the heavy naphtha are reached; and in general it may be said that there was no significant difference for the various commercial fuels. In the case of the benzol blend, all runs made indicate that the slightly higher carbon value obtained with this fuel is significant. It should be said, however, that the deposit obtained was softer and more soot-like than those from other fuels.

The reason for using natural gas in this series was

TABLE 5—TEST RUNS WITH DIFFERENT FUELS; OTHER CONLITIONS DUPLICATED

Fuel	Oil Consumption, Cc.	Head Carbon, Grams	Head Carbon Value, per Liter of Oil, Grams
Natural Gas	190	1.474	7.7
Casinghead Gasoline	190[d]	1.650	8.7
Special Gasoline	240	1.954	8.1
Light Gravity Blend	250	2.063	8.2
Motor Gasoline	260	2.178	8.3
Benzol Blend	310	2.879	9.3[e]
Cleaners' Naphtha	190	2.778	14.6
Kerosene	290	4.147	14.3

Air-fuel ratio, 12 to 1. Duration, 15 hr. Head temperature, 400 deg. fahr. Room temperature, 73 deg. fahr. Speed, 1090 r.p.m. Power, 700 watts. One lubricating oil.

[d] Control of the supply of this highly volatile fuel was irregular.

[e] In the benzol runs the air-fuel ratio was not corrected for the 10-per cent difference in gravity between the benzol blend and motor gasoline.

TABLE 6—TEST RUNS WITH DIFFERENT LUBRICATING OILS AND RICH AIR-FUEL MIXTURE

Oil	Oil Consumption, Corrected for Dilution, Cc.	Dilution, Per Cent	Head Carbon, Grams	Head Carbon Value per Liter of Oil, Grams	Total Oil-and-Ash-Free Carbon Value, per Liter of Oil, Grams
		Motor Fuel			
No. 1 Pennsylvania Distilled	330	12.5	5.051	15.3	16.3
No. 2 Mid-Continent Blend	330	12.0	5.628	17.0	15.4
No. 3 Gulf Coastal	320	11.5	2.663	8.3	9.6
		Special Fuel			
No. 1 Pennsylvania Distilled	270	8.0	4.652	17.2	16.7[1]
No. 1 Pennsylvania Distilled	300	8.5	4.034	13.4	12.8
No. 3 Gulf Coastal	290	9.5	1.792	6.2	8.7
No. 3 Gulf Coastal	280	8.5	2.062	7.3	9.7

Air-fuel ratio, 10 to 1. Duration, 36 hr. Head temperature, 365 deg. fahr. Oil temperature, 86 deg. fahr. Room temperature, 73 deg. fahr. Cylinder cooling-water temperature, 54 deg. fahr. Speed, 1140 r.p.m. Power, 700 watts.

[1] The head temperature was low during this run.

to obtain figures on a fuel that would be expected to leave little or no fuel carbon. It is surprising to note that the carbon value for natural gas is only about 5 per cent less than those obtained for the commercial gasolines. This may be interpreted to mean that in a 12-to-1 mixture a good average grade of gasoline plays a very small part in the deposition of carbon. The excessively high values obtained with heavy naphtha and kerosene are believed to be attributable to poor carburetion and the incomplete oxidation and probably asphaltization of sprayed liquid. The high result obtained with casinghead gasoline is not believed to be significant. Considerable difficulty was encountered in controlling the supply of this very "wild" liquid. The metering in the carbureter was erratic and the flow very irregular.

Influence of Oils and Mixture-Ratios

Rich Mixtures.—In this study the engine was operated under conditions intended to simulate those met by automobiles in ordinary cool weather. The mixture-ratio was set at 10 to 1, and all temperatures were kept low (see Table 6). The runs were of 36-hr. duration, in which time the dilution-equilibrium point had been passed. In spite of the heavy deposits formed, there was no evidence of loss of carbon due to flaking. In the series run on ordinary motor fuel, three representative commercial oils, of matched viscosity at 100 deg. fahr., were compared. It will be noted that the Pennsylvania distilled oil and the Mid-Continent blend gave head carbon deposits, and both head and total carbon values, considerably higher than those obtained with the Coastal oils. When a special gasoline, giving slightly less dilution was used as fuel, the deposits and carbon values were slightly lower, but the ratios of the carbon values among these three oils were approximately the same.

TABLE 8—NATURE OF CARBON DEPOSITS OBTAINED

Run	Oil	Petroleum Ether Extract from Carbon Deposits: Piston Carbon, Per Cent	Petroleum Ether Extract from Carbon Deposits: Head Carbon, Per Cent
DE-1	No. 1 Pennsylvania	34.9	16.2
DE-5	No. 1 Pennsylvania	32.7	17.2
DE-6	No. 1 Pennsylvania	43.0	18.7
DE-8	No. 2 Mid-Continent Blend	38.6	19.6
DE-2	No. 3 Gulf Coastal	25.1	13.5
DE-3	No. 3 Gulf Coastal	26.8	11.3
DE-4	No. 3 Gulf Coastal	26.3	11.0

It is interesting to observe that with the same fuel, and under the same conditions, the different oils suffered crankcase dilution to the same extent. These dilution figures were obtained by use of the Sligh vacuum-distillation test, which we have found to be accurate to ±0.5 per cent.

Lean Mixtures.—In Table 7 are given deposits and carbon values for experiments made under conditions simulating efficient summer engine-operation. The mixture was relatively lean and the head and oil tempera-

TABLE 7—TEST RUNS WITH DIFFERENT LUBRICATING OILS AND LEAN AIR-FUEL MIXTURE

Oil	Oil Consumption, Cc.	Total Head Carbon, Grams	Head Carbon Value, per Liter of Oil, Grams	Total Oil-and-Ash-Free Carbon Value, per Liter of Oil, Grams
No. 4 Pennsylvania Blend	310	2.970	9.5	8.5
No. 4 Pennsylvania Blend	270	2.177	8.0	6.5
No. 4 Pennsylvania Blend	160	1.480	9.2	7.5
No. 4 Pennsylvania Blend	270	2.245	8.3	7.4
			Average 8.7	Average 7.5
No. 5 Mid-Continent Distilled	310	1.605	5.1	5.5
No. 5 Mid-Continent Distilled	250	1.211	4.8	5.3
			Average 4.9	Average 5.4
No. 6 Gulf Coastal	280	0.776	2.8	3.7
No. 6 Gulf Coastal	350	0.914	2.6	3.6
No. 6 Gulf Coastal	300	0.905	3.0	4.1
			Average 2.8	Average 3.8
No. 1 Pennsylvania Distilled	260	2.178	8.4	7.7
No. 2 Mid-Continent Blend	260	2.258	8.7	8.8
No. 3 Gulf Coastal	260	0.867	3.3	4.0

Air-fuel ratio, 12 to 1. Duration, 15 hr. Head temperature, 400 deg. fahr. Room temperature, 73 deg. fahr. Oil temperature, 73 deg. fahr. Speed, 1090 r.p.m. Power, 700 watts. Motor gasoline.

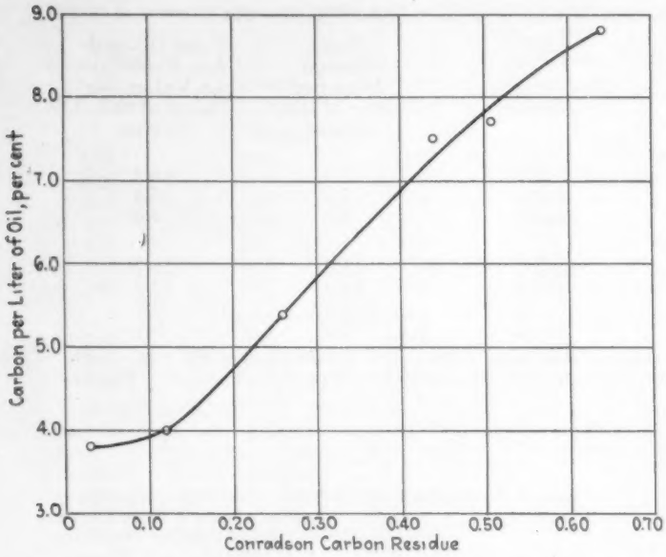

FIG. 5—RELATION OF CARBON-DEPOSIT VALUE TO CARBON RESIDUE OF THE OILS
The Greater the Distillation Residue by Conradson Test the Greater Is the Deposition of Carbon in the Engine under Identical Operating Conditions

tures rather high. The three oils compared at rich mixture-ratios and three additional oils of corresponding origin and of slightly lower matched viscosity were used. It will be seen that the carbon deposits and carbon values for oils Nos. 4, 5 and 6 decrease markedly in the order: Pennsylvania blend, Mid-Continent distilled and Gulf Coastal, the oil-and-ash-free carbon value of the Pennsylvania oil being twice that of the Coastal oil, and the Mid-Continent distilled falling half way between. For the comparison of Pennsylvania distilled, Mid-Continent blend and Gulf Coastal, as represented by oils Nos. 1, 2 and 3, the Coastal oil was found to give carbon values approximately half those for the other oils. By comparing Table 6, it will be noted that this ratio holds for rich mixtures, where the fuel and the combustion temperatures play a part in the deposition, as well at the leaner mixtures, where the carbon deposit is attributable almost exclusively to the lubricating oil.

BEARING OF VOLATILITY OF THE OIL

In Table 8 are given extraction figures on carbons obtained at rich mixtures corresponding, apparently, to the running conditions of most automobiles. These figures show that the carbons from Gulf Coastal oils contain less oily matter than do the other less volatile oils. This is believed to be due to the greater volatility of the Coastal oil which permits it to boil away without leaving much deposit. This may also explain the varying nature of the carbon deposits from the different oils. In all the runs made, no matter what the conditions, the carbon from the Coastal oils was, in general, dry, powdery and friable over the hot metal-areas and only slightly more coherent over the cooler areas. Carbon from the Pennsylvania oils, on the other hand, was extremely hard and adherent over the hotter areas and sticky and asphaltic in appearance over the cooler areas. It is believed that the sticky nature of this deposit would cause retention of a higher proportion of dust.

It has been suggested that the Conradson carbon-residue of lubricating oils offers an approximate measure of the tendency to deposit carbon in an automobile engine, but little experimental support for this supposition has hitherto been published. The curve in Fig. 5, however, confirms this view.

Fig. 6 gives the distillation data at 10-mm. (0.3937-in.) pressure for the oils used, in two groups of matched viscosities at 100 deg. fahr. It will be noted that the Coastal oils, which gave the lowest carbon-deposits, have also the lowest boiling-temperatures. It is particularly significant that those oils which are almost completely volatile below the cracking temperature gave considerably lower carbon values than those containing appreciable proportions that are non-volatile below the cracking range.

We believe there is a close connection between the volatility of an oil and its carbon-depositing tendency. If an oil contains a fair proportion of hydrocarbons that are non-volatile at the prevailing temperature of the metal surface, such as a steam-refined cylinder stock, this residue will progressively crack and oxidize to sticky and asphaltic materials which will gradually bake into dense, adherent deposits. If, on the other hand, the oil can distil off fairly cleanly, it probably will take much longer to produce a deposit of equal thickness. In addition, it appears that a deposit from such a volatile oil will contain a smaller quantity of binding material, will be more friable than a deposit from a higher-boiling oil and will therefore be carried off to a greater extent with the exhaust.

From this study it would appear that the popular belief concerning the connection between the so-called heat-resisting properties of an oil and its desirability is probably erroneous. No lubricating oil can be expected to remain undecomposed at the flame temperatures prevailing in the combustion-chamber. The oil, therefore, which will leave the smallest residue on evaporation from the metal surfaces will give the least trouble.

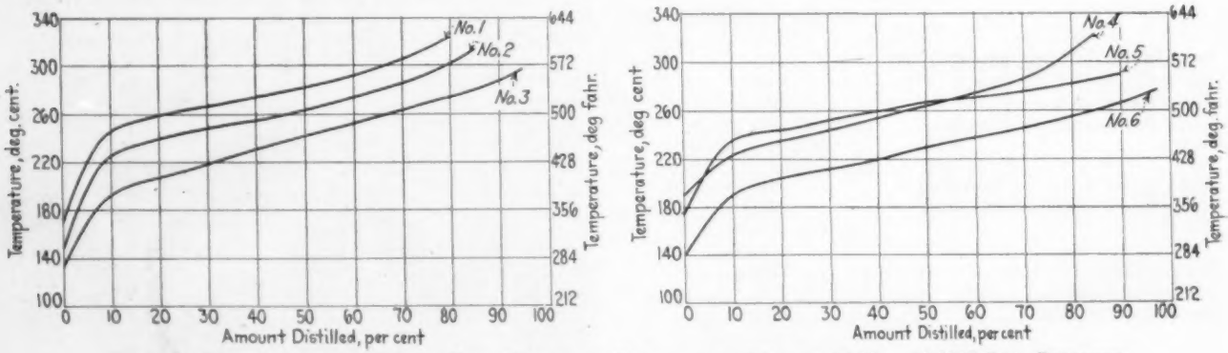

FIG. 6—DISTILLATION CURVES OF TWO GROUPS OF LUBRICATING OILS AT 10-MM. (0.3937-IN.) PRESSURE
No. 1, Pennsylvania Distilled
No. 2. Mid-Continent Blend
No. 3. Gulf Coastal
No. 4. Pennsylvania Blend
No. 5, Mid-Continent Distilled
No. 6, Gulf Coastal
The Gulf Coastal Oils, Nos. 3 and 6, Which Have the Lowest Boiling-Temperatures, Gave the Lowest Carbon-Deposits. Those Oils That Are Almost Completely Volatile below the Cracking Temperature Gave Considerably Lower Carbon-Deposit Values Than Those Containing Appreciable Proportions That Are Non-Volatile below the Cracking Range

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Complementary-Color Headlighting

By K. D. CHAMBERS[1]

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS

ABSTRACT

THE complementary-color headlighting system is based upon the use of differentiated light, that is, light having different wave-lengths. Each head-lamp is oval and contains two paraboloid reflectors, one emitting light through an orange glass filter, the other through one of blue glass. While driving at night, the driver looks through a viewing-filter of transparent glass of the same color as that of the headlight which is in use. The viewing-filters are arranged so that whenever one is used, the headlight of the same color is automatically turned on. When the headlights are not in use, the filters are held in the filter-box and are out of sight. It is the intention that cars traveling in a general direction, say north and east, shall use the blue light; that those traveling south and west shall use the orange light. Each viewing-filter is transparent to the light that is thrown on the road by the headlights of the same car but is opaque to the lights of approaching cars. The result is that ample illumination is provided for perfect visibility but no glaring lights from approaching cars can reach the eyes of the drivers.

Selection of the proper headlight is simplified by the fact that the color of the headlights is controlled by the viewing-filter used and a driver must protect oncoming drivers to obtain protection himself. Conformity is necessary to obtain personal safety.

When meeting cars that are unequipped with the new system, the viewing-filter allows only about 25 per cent of the incident white light to pass, and unequipped cars are at no disadvantage because the luminous flux with the new system is not more than that supplied by the standard lamps in use at present.

Tests of the apparent brightness of a target placed 3 ft. to the right of the head-lamps at a distance of 70 ft. show that, in order to have the same target equally visible under both systems, the ratio of its apparent brightness in the old and in the new system must be as 25 is to 1.

Red danger-signals are visible through either viewing-filter and are distinguishable from lights of other colors, such as orange, yellow, white, green, or blue.

As color blindness is not a lack of the sensation of luminosity but of hue sensation in certain portions of the spectrum, a person who could not distinguish a red light while using the complementary-color system could not do so while using the present system.

Among other topics given consideration are the danger due to a low distribution of light, especially when encountering pedestrians on the road at night; the economic and sales factors involved in a change of headlighting system; the general subject of visibility and the limitations of the eye; the danger arising from the dimming of headlights due to the time required for the "threshold" to drop; the relative proportion of deaths and accidents caused by conditions of poor visibility; and the sales advantage offered by the increased comfort and pleasure of night driving with the new system.

In conclusion, a comparison is made between the use of undifferentiated headlighting and a radio broadcasting station that is allowed to broadcast over the whole range of wave-lengths; and stress is laid on the point that no consideration of inconvenience or trivial increase of cost can justify the continuance of the present system with its record of accidents and fatalities.

THE complementary-color headlighting-system is a method for enabling automotive vehicles to illuminate the road and, simultaneously, enabling the drivers to protect their eyes from the rays of other similarly equipped vehicles under all road conditions by differentiated light, that is, light having some peculiar characteristic that makes it behave in a different manner from that of some other form of light. In the system under discussion, the light is differentiated by wave length. A driver is afforded protection for the reason that two forms of differentiated light are used, one of which is allowed to pass freely through a viewing-filter by which the other is almost completely absorbed. In this system, each head-lamp is oval and contains two paraboloid reflectors. The upper one contains an orange glass filter in place of the ordinary clear-glass lens; the lower one has a blue glass filter. Fig. 1 shows these very clearly.

In front of the driver, just inside and at the top of the windshield in the same vertical median plane as the direct line of sight of the driver, is a filter-box containing the viewing-filters through which the driver looks while driving at night over dark roads. These viewing-filters are flat sheets of transparent colored glass. Fig.

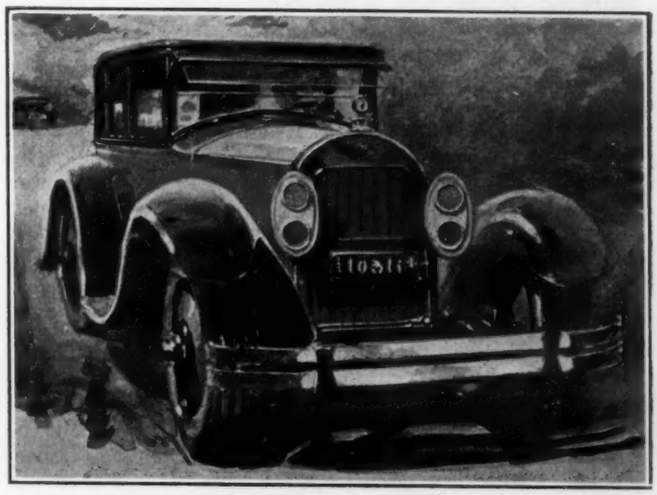

FIG. 1—APPEARANCE OF CAR EQUIPPED WITH COMPLEMENTARY-COLOR HEADLIGHTING-SYSTEM

The Upper Head-Lamp Contains an Orange Glass Filter, Instead of the Customary Clear-Glass Lens; the Lower One Has a Blue Glass Filter

[1] Scientific research engineer, Ashville, N. C.

2 shows the location of the filter-box and one of the filters in place for driving. The size of these filters will be the one that is finally decided upon as the best but, at present, 6 x 12 in. is advocated.

Filters Matched Automatically

The viewing-filters are arranged so that when either is drawn down and the driver is looking at the road through it, the headlights of the same color are automatically turned on, electrically not mechanically. When either filter is pushed up, by simply raising the knob as shown, the other one drops into the viewing position and the lights are changed automatically. When the headlights are not in use, both filters are held up in the filter-box and are out of sight.

If a car is going north, let us say, and is conventionally using blue headlights, the driver must look through a

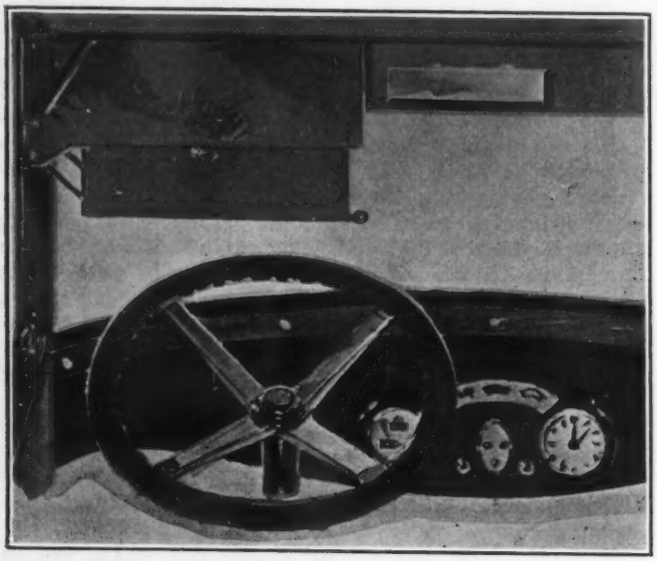

Fig. 2—Relative Location of Viewing-Filter and Filter-Box
The Viewing-Filter Is Composed of Flat Sheets of Transparent Colored Glass. The Size Will Be That Ultimately Decided Upon as the Best but, at Present, 6 x 12 In. Is Advocated

blue filter. His blue viewing-filter is completely transparent to light of the wave-length that his headlights are throwing on the path of the car. Consequently, he can see practically as well as if he were driving with white lights and looking through an ordinary windshield under the ideal conditions of no opposing car to cause glare. A car coming south now approaches. On account of the fact that it is southbound, it will use orange headlights and the driver of it must necessarily look through his orange viewing-filter. Consequently, that driver can see the road as illuminated by his orange headlights perfectly.

Opaqueness of the Viewing-Filter

The orange light of the southbound car, however, will not pass through the blue viewing-filter of the northbound car and the blue light of the northbound car will not pass through the orange viewing-filter of the southbound car. The result is that both drivers have perfect visibility, because no glaring light can now reach the eyes of the drivers and raise their "thresholds." Consequently, under the conditions of this new system of complementary-color headlighting, the illumination is sufficient to produce ample visibility and comfort with safety.

On a road at night, when the driver of a car equipped with this system approaches another car similarly equipped, he will see the other car and objects along the road very clearly and will be able to see the boundaries of the road and its surface practically as well as if his car were throwing a brilliant white light ahead and he were looking through the conventional clear windshield at a car with its lights dimmed almost to extinction. The headlights of the approaching automobile will appear as if lighted with an old-fashioned kerosene lamp having a very much smoked-up lamp-shade. In case one of the reflectors of the oncoming car happens to form an image of the filament, after the cars have come close together this will appear clearly visible to the driver and will seem to be faintly glowing but will produce absolutely no glare.

In actual tests, the number-plate between two headlamps could be read perfectly and persons sitting on the rear seat of an approaching car were easily recognizable.

The apparent brightness of the headlights of the approaching car was so low that one could look at them and then look aside without being able to perceive any after-image. More perfect conditions of visibility at night could hardly be imagined.

Selection of Filter Simplified

The question, how shall a driver know which viewing-filter and which lights to use, has a much simpler solution than would at first seem possible. Two facts narrow the solution to simple limits.

The first is, that a driver cannot use a filter of one color and forget to change the color of his headlights, because the change of color of the headlights is automatically controlled by the viewing-filter used; consequently, a driver must protect the oncoming driver to obtain protection for himself.

The second fact is, that the whole problem is automatically narrowed to very small communities; in other words, it is localized. If given some simple general rule for making this determination, such as,

> A car traveling in a direction generally north or east will burn blue headlights and a car going in the opposite direction will burn orange headlights;

the people of each community can, in a few moments, determine once and for all which light should be burned while going in either direction over the roads and streets of their own localities. In case of fine distinctions, the local municipal authorities or automobile clubs will quickly and easily settle the matter.

Consequently, an automobilist driving a car at night in a strange locality will not be in doubt as to which headlight color he should use, because he will have to use the proper filter to protect himself from the lights of the local cars coming toward him, and his headlights will automatically match the viewing-filter selected. On the principal highways, conventions will be established as to the light to be used while going in the different directions. It might be decided, for instance, that any car westbound on the Lincoln Highway should burn orange lights, and that any car eastbound on the Lincoln Highway should burn blue lights. Consequently, a driver could drive clear across the Country over the Lincoln Highway and never have to change his lights.

Signs erected at the principal road-intersections could have the word, "blue" or "orange," added to them, or simply the initial, "B" or "O." Such a sign would read, for instance, "Albany-Route 12-B." Consequently, a driver would know that he should burn blue lights as long as he traveled over this road in that direction.

Psychological Factors Favor New System

In the very fact that a driver must conform to this system if he is to obtain personal safety and comfort lies another great advantage that this system enjoys over those now in use. With present systems, it is to the advantage of a selfish person to ignore the safety and he can obtain better visibility, at the expense, however, comfort of an oncoming driver, in fact, to break the law. For, by improperly adjusting his headlights or by using bulbs of greater candlepower than the law allows, of oncoming drivers. With the new system, it is to the advantage of even a selfish person to comply with the law and to protect the oncoming driver, because only by doing so can he protect himself.

This psychological factor is of very great importance as anyone who has had many dealings with the public will realize. To pass laws requiring a man to do something that is distinctly to his disadvantage and at the same time appears to give him no compensating advantage, is one thing; to enforce the laws is certainly a different matter.

Any driver of a car equipped with this new system, without a question of a doubt, will be so pleased when he passes on the road another car similarly equipped, that his entire sympathy and influence will be automatically enlisted in favor of equipping all automobiles with this system. In fact, whenever he passes a car with a particularly glaring headlight, his animosity will be aroused to a much greater extent than it has been in the past, because under the new conditions he will know that the offense is a wilful one and is entirely unnecessary.

Equipment with New System Gives Immediate Advantage

The driver of a car equipped with this system will have an immediate advantage over the driver of a car equipped with the old system because of the fact that his viewing-filter allows approximately only 25 per cent of the incident white light from the headlights of the unequipped car to pass through, while it permits most of the light from his own car to pass through; but, of course, the protection will not be so great as it would be if both cars were equipped with this headlighting system.

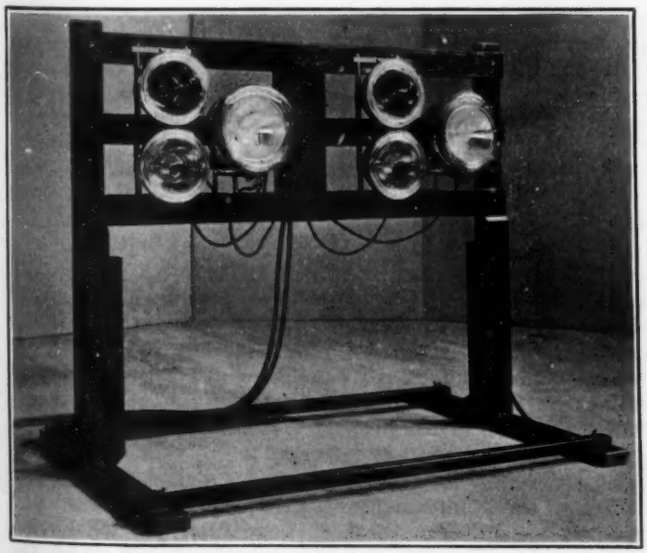

Fig. 3—Laboratory Test-Equipment for Comparing the Complementary-Color Headlighting-System with the White-Light System, Showing Visibility Meter and Test Tail-Light
To the Right of Station B, as Observed from Station A, and 3 Ft. from the Center of the Closest Head-Lamp, Was Placed an Apparatus for Testing Threshold Values

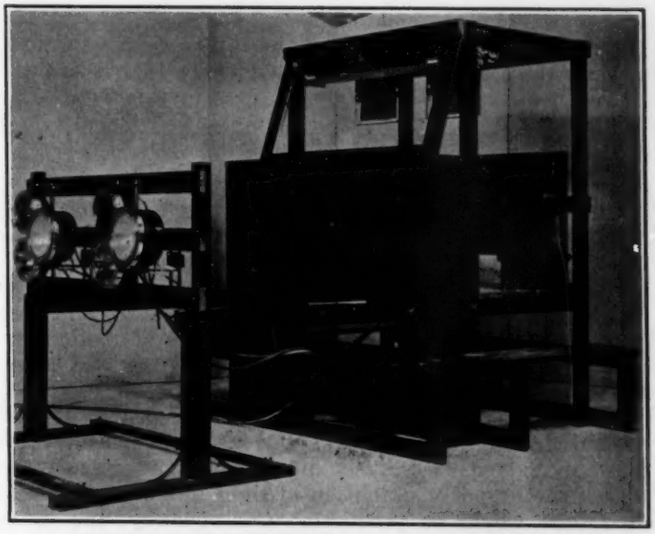

Fig. 4—Laboratory Test Equipment, Showing Test-Car, Viewing-Filters, Head-Lamps, and Control Wires
Stations A and B, During the Tests, Were Set 70 Ft. Apart

The driver of an unequipped car facing the drivers of equipped cars will not be under any greater disadvantage than he is at present, because the viewing filter prevents the blinding scattered light from the oncoming car reaching the eyes of the driver.

Water Drops and Dirt Do Not Produce Low Visibility

An interesting and important advantage that the complementary-color headlighting-system has over the present system is the fact that small particles of water, dust or smoke, in the line of sight, do not produce low visibility due to veiling glare, because these particles reflect or refract the light from the head-lamps of oncoming cars into the eyes of the driver, and consequently blinding him to certain extent.

With the new system, rain drops on the windshield and dense tobacco smoke inside the car produce very little effect on the vision of the driver. If a smoking cigarette is held below the driving filter, the smoke is visible just as in the old system until it strikes the viewing-filter and then disappears almost entirely. In our demonstration model, the windshield was smeared with dirt and dust and the car was arranged so that a change could be made from the new to the old system almost instantly. This windshield, when viewed from the driver's regular position under the old system of lighting, seemed to be extremely dirty. When the new system was used, the dirt almost disappeared as if by magic. The advantage in practical use given by this fact is a rather important one under certain weather and other conditions.

In a consideration of the appearance of the headlights and of the distribution of the light flux, certain conditions should be kept in mind. In the first place, it must be admitted at the outset that, if it were possible to control the distribution of the light flux from, let us say, a northbound car using white light, so that none of the light went into the eyes of the driver of an approaching southbound car, and if it were possible similarly to control the light flux at all times and under all the conditions met with in actual road-driving, no lighting problem would have to be solved.

If the intensity of a light beam is high enough to produce the necessary illumination, it certainly is more than enough to blind. Consequently, no system using un-

differentiated light can be designed which can produce the conditions necessary to good visibility, no matter how cleverly the distribution under the ideal conditions is controlled.

Control of Distribution of Undifferentiated Light Extremely Improbable

Our experience has proved conclusively that such control by distribution is extremely improbable. H. M. Crane, technical adviser to the president of the General Motors Corporation, has pointed out that, even after a long period of enforcement in New York State and the consequent arrest and fining of thousands of motorists, almost no appreciable increase in the visibility and comfort of night driving has taken place. L. C. Porter and G. F. Prideaux, in their splendid paper[2] presented at the Annual Meeting of the Society, demonstrated conclusively that only extremely fine maladjustment was necessary to distort the proper distribution of light flux so that glare conditions would be produced. Consequently, the conditions with which we must work are not ideal but are those under which ideal conditions fail to operate. If roads were always smooth and flat and always had a black mat surface, if the lights were always in proper adjustment and burned legal candlepower light-bulbs at their specified voltages, as has already been said, no problem would have to be solved. The problem confronting the engineer is one of equipping cars with lighting devices that will produce good visibility under adverse conditions and will give an oncoming driver the benefit of the doubt in all cases. In other words, if lamps are out of adjustment, the device used should be such that the driver of the offending car will suffer from the maladjustment, not an oncoming driver.

Consequently, the glare studied should be the average maximum glare produced under the normal fluctuations caused by maladjustment. Visibility should be studied under the conditions obtaining when the average maximum glare is in the eyes of the driver and he is seeing with lights that range through the average maladjustment of his own headlights.

Laboratory Work and Filters

Very careful tests and measurements of this system have been made under laboratory conditions. The tests covered many very complicated factors relating to threshold sensitivity, photometric sensitivity, glare sensitivity, and the combined effects of these different attributes of the eye at the same and different levels of illumination and factors of reflection of the objects viewed.

It would be impossible to put into a report of this length all the factors and relations that have been considered in the study of this problem and the development of the means that have been adopted to solve it. The author wishes to express his great indebtedness to L. A. Jones, head of the physics department of the research laboratories of the Eastman Kodak Co., for his very capable assistance in these studies over a period of more than 3 years.

Perhaps the most outstanding measurement is the apparent brightness of a target just visible when viewed under the conditions of the old system as compared with the apparent brightness of one just visible and viewed under the conditions of the new. The ratio between these apparent brightnesses is 25 to 1. In other words, the apparent brightness of a target, situated 3 ft. to the right of the head-lamps of complementary color at a distance of 70 ft. and viewed through one of the viewing-filters of the new system is, let us say, 1. That this same target may be visible, when viewed through a perfectly clean clear-glass windshield, when white lights of standard legal type have been placed similarly to those in the previous test and have been pointed in a similar manner to produce glare, the apparent brightness of the target must be 25.

Laboratory Demonstration Equipment

To make careful analyses of the visibility conditions, an apparatus was constructed, as shown in Figs. 3 and 4, which are respectively stations B and A, the arrangement of the two illustrations being such as to show their relative positions. Fig. 5 shows the switchboard in station A, the viewing station. As these illustrations show the whole apparatus clearly, it will be unnecessary to go into a long description of them. Stations A and B, during the tests, were set 70 ft. apart. To the right of station B, as observed from station A, and 3 ft. from the center of the closest head-lamp, was placed an apparatus for testing threshold values. This piece of apparatus consisted of a light source, known and variable diffusing media and a large iris diaphragm. As viewed from the front, a dead black arrow about 1 ft. long is visible against an opal glass illuminated by the light in the instrument or against surfaces of different and known factors of reflection.

Station A, as can be seen in the illustration, was equipped with a device for allowing either viewing-filter to be used, and is connected so that, if a blue filter is used, the blue lights in A and the orange lights in B will be simultaneously turned on and vice versa. It is also connected so that, if the viewing-filter is swung up out of the line of sight, so that a clear view through the viewing-filter is obtained, the white lights at both stations A and B will be turned on. Plugs were connected across all the lamp contacts so that the voltages could be watched carefully. The blue headlights were equipped with carefully tested 50-cp. light-bulbs, the white ones with standard 21-cp. bulbs. The absorption of the transmitting filters was such that in no case was the luminous flux from the colored lamps equal to that of the white headlights.

All lamps were adjusted for conditions of maximum glare and the adjustment was carefully made so that, by photometer tests, the illumination on the target in each case was the same as that on a plane directly in front of the eyes of the driver. The relative visibility obtained under these conditions is equal to the reciprocal of the factors of reflection of the test cards used behind the black arrow.

Results of Tests Showing Relative Visibility

Briefly, the tests showed that, with white light, a card having a factor of reflection of 0.255 was scarcely visible and, consequently, the relative visibility was 3.92. It was found further that, if the viewing card were moved to within 2.5 ft. instead of 3.0 ft. of the nearest head-lamp, the card of the highest factor of reflection that we had, which was 0.850 and was as white as a white shirt, was completely invisible.

When the complementary-color system was used and a view was taken with the orange filter, a card having a factor of reflection of 0.040 was visible, of which the relative visibility, consequently, was 25.0; and with the blue filter a card having a factor of reflection of 0.032 was visible, the relative visibility of which, consequently, was 31.2.

[2] See The Journal, February 1926, p. 222.

Standard Danger-Lights Visible

Filters have been developed that are mutually absorptive, yet each allows the passing of rays at the extreme red end of the spectrum. This enables a Railway Signal Association standard red danger-signal to be seen through either one and, furthermore, to be distinguished from an orange, a yellow, a white, a green, or a blue light. That does not mean that a yellow light can be distinguished from a green light by hue through the orange viewing-filter, but it does mean that a standard danger-light can be distinguished as such by hue from the other colors through either the orange or the blue viewing-filter.

Color Blindness No Objection

The effect of color blindness on the complementary-color headlighting-system has been studied carefully with the following results. Color blindness is a lack of ability to designate or discriminate colors. It is not a lack of the sensation of luminosity but of hue sensation in certain portions of the spectrum. Dr. Ernest Clarke, surgeon to the Central London Ophthalmic Hospital says:

> Absolute inability to distinguish color is rare, if it exists; Daltonism, or red-green blindness, of which there are two varieties, the red blind and the green blind, is the more common defect. Red appears to a red-blind person as a dark green or greenish-yellow; yellow and orange, as dark green; and green is greener and brighter than the green of the yellow and orange.

Consequently, a person who could not distinguish a red danger-light while using the complementary-color headlighting-system could not distinguish a red light while using the present system and vice versa. As stated elsewhere in this paper, red can be seen as red through either viewing-filter.

Danger in Low Distribution of Light

Just a word about the present distribution of light may be timely. Most pedestrians along the roads at night are men, and, even in summer when they are coatless, the portions of their clothing having the higher factors of reflection are above the waist. It is very desirable, consequently, to use ample light-flux above a line horizontal with the centers of the head-lamps. The question of seeing a pedestrian is very important, for more than 60 per cent of all fatalities caused by automobiles in 1925, were of pedestrians. These figures are from the report of the National Automobile Chamber of Commerce issued in March, 1926.

Economic and Sales Factors

The present manufacturers of head-lamps need have no hesitancy in advocating a change to the new system, for it will be most decidedly to their advantage to have the new system universally adopted as speedily as possible. Approximately 20,000,000 automobiles are now in actual use in the United States, approximately 4,000,000 of which were put into use in 1925. About 2,000,000 are discarded annually. Consequently, if the change-over to the new system should occupy 3 years, 26,000,000 cars must be equipped during this period. This will be at the rate of 8,600,000 a year, the increment in car mortality being included. The increase in car production in 1925 over the 1924 figures was exceptional and amounted to about 20 per cent. Figuring, however, at the more normal rate of 12 per cent per year, the production at the end of the 3-year period would amount to 5,850,000 cars for the year. The necessary increase in productive machinery would, therefore, not be beyond sound and safe economic limits, as the resultant decrease in the market at the end of the 3-year period would be both foreseen and easily compensated for by the usual economic methods in such cases.

Almost all lamp manufacturers could, with small relative cost, change their particular model or style of head-lamp to the new-type lamp. With profits figured on a percentage of the gross sales figures and some increase in the cost of equipment, their profits would be enhanced considerably.

Illumination and Visibility Not Synonymous

On account of the physiological and psychological factors entering into vision, the problem of providing a means of illuminating the path of an automobile and of also simultaneously providing the necessary conditions for adequate visibility are not synonymous. We all know that the human eye is extremely sensitive to electromagnetic waves having a wave-length from 400 to 700 millimicrons, provided that no portion of the retina is being excited by a much more powerful stimulus.

Nature has provided the eye with mechanisms that automatically adapt it to the proper sensitivity, which is necessary for good visibility over a wide range of illumination for objects of secondary illumination of all the reflection factors. In other words, objects can be seen well and distinguished as to shape and contrast by reflected light even when the brightness of the objects varies greatly. The eye responds to stimuli ranging in magnitude in the ratio of 1 to 10,000,000,000. If, however, the difference in the brightness of the objects is very great and, consequently, a great difference in the

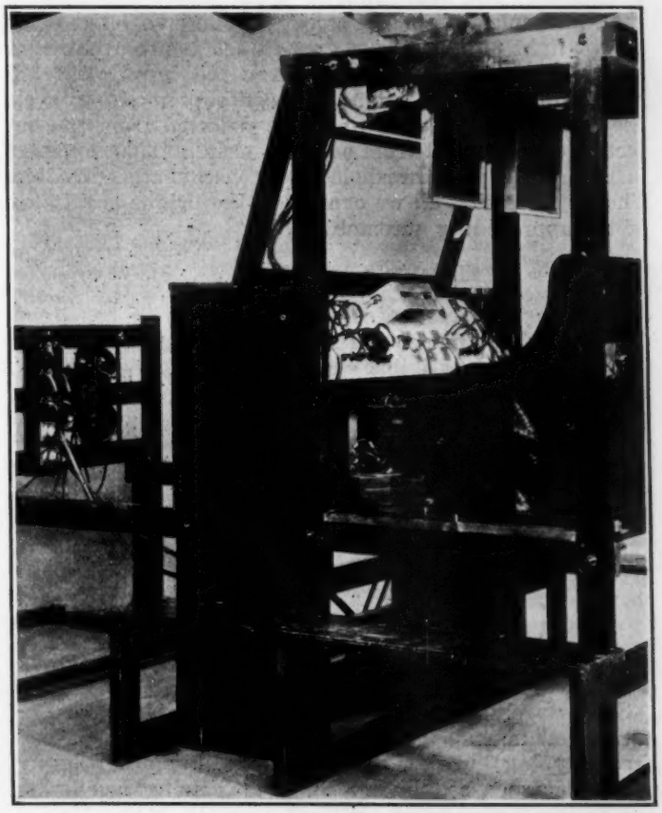

Fig. 5—Side Rear View of Test-Car, Showing Test-Control Mechanism

A Device Allowing Either Viewing-Filter To Be Used Was Connected So That, If a Blue Filter Is Used, the Blue Lights in A and the Orange Lights in B Will Be Simultaneously Turned On and Vice Versa

brightly and dimly illuminated retinal-areas exists, particularly if the brightly illuminated retinal-area is relatively small and fairly near the fovea, the conditions put a great strain on the automatic adaptive mechanism of the eye, and poor visibility, discomfort and even pain result.

Furthermore, we know that when the eye has adapted itself to a certain level of retinal flux, all objects below a certain brightness are invisible, that is, insofar as their ability to produce a subjective sensation of light is concerned. If objects can be seen at all then, it is only on account of their outline, in the same manner that a black hole in the side of a brightly illuminated white wall can be seen.

Limitations of the Eye

We all are familiar with the fact that a person who goes directly from a bright sun-lighted street into a dimly illuminated theater is temporarily blinded. After being in the theater for a few minutes, however, he can see fairly well. This example illustrates the working of the adaptive mechanism of the eye. The threshold was "high", as the psychologists say, when he first went into the theater. After he had entered the theater, it began to "drop". An important time-element enters into this change of threshold level that will be considered later. It should be realized, however, that the adaptive ability does not consist solely of the pupillary contracting and expanding mechanism. In fact, the threshold changes in the retina or nervous mechanism are capable of a much greater range of operation.

Automobile headlighting is much the same as that of a theater. The headlights of a car afford illumination that is ample to produce good visibility so long as no bright light shines in our eyes. Just as soon, however, as another automobile comes over the brow of a hill and throws a beam from its headlights into our eyes, the threshold rises, and the light reflected from the objects along the road from our own headlight illumination is now below the threshold and consequently invisible. The result is that all we can see is the bright headlights of the approaching automobile.

Dimming Is Dangerous

Dimming has been of almost no value and has great dangers. The time required for the threshold to drop is by no means negligible but, under ordinary conditions, is a magnitude approximating from 3 to 5 sec., even when a white object having a factor reflection of 0.85 is observed. Consequently, if both drivers dim their lights at exactly the same time, while traveling at a speed of 30 m.p.h. each will cover from 132 to 220 ft. while practically blind. These considerations, in their purely analytical aspect, should be enough to convince us that a great and urgent need exists for making whatever changes in our systems of headlighting are necessary to produce good visibility.

Deaths and Accidents Due to Poor Visibility

Some purely practical considerations, however, are of paramount importance. In the last 2 years, two national press-clipping bureaus have gathered clippings relating to accidents caused by improper or glaring headlights and to legislation on the subject over the entire United States. The accumulated material is appalling.

The National Automobile Chamber of Commerce, in March, 1926, issued a report on motor fatalities in 1925. In Table 3 of this report, an analysis of the causes of 5346 deaths showed that 137 were due to fog, rain or snow; 37 to strong lights on vehicles; 19 to poorly lighted streets; and 10 to confusion in dimming. This makes a total of 203 deaths due almost directly to conditions of visibility. In the same proportion then, 3.89 per cent, or approximately 757, of the 19,828 motor fatalities during the year must have been due to bad conditions of visibility. This is at the rate of more than 2 deaths each night in the United States alone. As everyone knows, only a small percentage of the automobile accidents actually result in death. The January, 1926, report of the National Conference on Street and Highway Safety states that the ratio is 25 accidents to 1 fatality. In 1925, at this rate, 18,925 accidents were due to this cause. This phase of the matter need not be dwelt upon further, as everyone is familiar with the constant peril due to poor visibility at night. The most important factor, of course, is the tense nervous strain that the driver is under and the fear that causes him to lose most of the pleasure of driving. Statistics show conclusively that this fear is well-founded.

Nerve Strain an Important Sales Factor

Entirely outside the consideration of the saving of life, limb and property is the very practical sales question of increased comfort and pleasure in night-driving and the consequent increase in the sales of automobiles. Many persons at present do not buy automobiles because they are at work during practically all the daylight hours and are afraid to drive at night. More driving at night would shorten the useful life of an automobile and, consequently, would have the effect of increasing sales.

Conclusion

In conclusion, it is my opinion that it should be illegal for anyone to place on an automobile any lighting equipment that would enable him to project down a road an undifferentiated beam of light against which another driver cannot protect himself. It amounts to almost the same thing as permitting a broadcasting station to broadcast over the whole range of available wave-lengths. The principal difference is that, in the case of broadcasting, the result is one of annoyance; whereas, in the case of undifferentiated light, the result now many times nightly is one of death, injury and destruction. The system of complementary-color headlighting solves the problem of providing adequate visibility at night for automobilists in a scientific and practical way. Most persons now drive at night because they wish to go somewhere. With the new system, persons will drive at night for the sheer pleasure of driving.

The consideration of the period of change from the old to the new system has been the principal and, in fact, the only argument that has been advanced against this new system. The existing laws and specifications were written to make the best of a bad situation. Now that we have a method of completely solving the problem, many of them are not only valueless but a bar to progress.

Certainly with 18,925 accidents and 757 deaths, or even a small percentage of this number, no consideration of inconvenience or a trivial increase in cost can possibly justify the continuance of a system with such a record of anguish, despair and suffering of both the victims and their loved ones. Production, distribution and legislative considerations must be reckoned with, but it is only humane that the success or failure of this system should be determined on its merits.

Some Aspects of Aircraft-Engine Development

By G. J. MEAD[1]

AERONAUTIC MEETING PAPER

THE discussion of this paper consists of remarks made immediately following the presentation of the paper at the Aeronautic Meeting that was held at New York City on Oct. 7, 1925, and two written contributions received since its publication in the November, 1925, issue of THE JOURNAL. In accordance with the usual practice, the stenographic report of the remarks made from the floor, as edited for publication, has been submitted to the speakers for their approval, and both verbal and written discussions have been submitted to the author of the paper for any additional comments that he cared to make. The corrected discussion with some additional comments received from the author is printed below. This completes the publication of the discussion of the papers presented at the Aeronautic Meeting.

An abstract of the paper precedes the discussion as an aid in understanding references made to statements in the paper for readers who may not have heard or read the paper and who do not care to refer to the complete text.

ABSTRACT

INFALLIBLE performance and economical operation are the bases of successful commercial flying. Airplanes, having passed through the experimental and demonstration periods, must now prove their usefulness. Heretofore, because of military requirements, designers have fostered the use of power rather than refinement of design to obtain performance, but commercial operation demands efficiency, and in each of the four essentials, namely, dependability, size, total powerplant weight and cost, opportunity for decided improvement still exists.

The requirements and limiting factors of each of these essentials are discussed in turn and the conclusion is drawn that a relation exists between the amount of thrust delivered to the air and the weight put into an airplane for its propulsion. To obtain the best over-all performance, if these terms are considered as a fraction, the numerator should have the maximum and the denominator the minimum value.

The suggestion is made that a more significant measure of efficiency than the weight per horsepower of the engine alone would be the wet weight of the engine per horsepower plus the weight of the cooling-system per horsepower plus the combined weight of the fuel and oil per horsepower per hour. The figure thus obtained would have no value, however, except as an indication of the over-all efficiency of the powerplant.

The general development of airplane powerplants is outlined, the various engines in vogue at present are classified into groups according to their horsepower, and the assertion is made that the air-cooled type of engine, having already displaced the water-cooled in the 200-hp. class, is likely to do so in the 400-hp. class. Designers of water-cooled engines are said to be endeavoring to overcome the handicap of excessive weight in engines of this type, but air-cooled engines, because of their greater dependability, are considered superior for commercial purposes.

In addition to increased dependability and reduced weight, the radial type of air-cooled engine makes possible an aerodynamically superior and symmetrical fuselage and gives a high center of thrust that allows ample propeller diameter.

In motor-car work, dependability and light weight are less essential than in the aeronautic field; consequently, the urge to develop them has not been so pressing. A leaky radiator in a motor car can be easily repaired but, if it necessitates a forced landing by an airplane, may lead to disastrous results.

Detailed descriptions, accompanied by illustrations, are given of a large number of American and foreign types of aircraft engine.

THE DISCUSSION

CHAIRMAN GROVER C. LOENING[2]:—The hope of airplane designers that attention would be given by automotive engineers to the development of air-cooled aircraft engines is apparently being realized slowly. The development that has been made in air-cooled engines, particularly in the last few years, is gratifying and promising.

CHARLES H. CHATFIELD[3]:—The point of view taken by Mr. Mead, that weight per horsepower is not the sole criterion of an engine, is very encouraging. It often happens that an engine which shows excellent power on the dynamometer may be very difficult to install in the airplane and involves so much extra weight that additional resistance in the airplane will go a long way toward nullifying the good qualities shown by the engine on the dynamometer. One reason for the popularity of the air-cooled engine, I think, has been the elimination of "plumbing" and the designer's task is easier, particularly on the military airplane in which space is so limited.

For commercial work, I think it will become more and more essential to design the airplane around the useful load rather than around the engine, as has been the common practice. Much better results will be obtained, especially if the engine is regarded as a part to be harmonized into the entire structure. Fundamentally, therefore, we should have engines that are designed for use in airplanes rather than for use with dynamometers.

EARLY AIR-COOLED ENGINES IGNORED

R. W. A. BREWER[4]:—In 1909, in the infancy of aviation, I designed a multiple-cylinder radial air-cooled engine and took out French and British patents covering that system. Some of the engines were built in France and one was shown in Paris in 1910, but European airplane designers did not want radial engines. The attitude was the same in America. I sent a man over here in 1911 with that engine design and nobody was interested. The following year I came over, when the air-cooled engine was considered more practicable, because the London *Daily Mail* $50,000-prize race was won with an air-cooled engine, and I found that other designers of

[1] M.S.A.E.—Vice-president, Pratt & Whitney Aircraft Co., Hartford, Conn.

[2] M.S.A.E.—President, Loening Aeronautical Engineering Corporation, New York City.

[3] M.S.A.E.—Airplane engineer, Wright Aeronautical Corporation, Paterson, N. J.

[4] M.S.A.E.—President and chief engineer, Engineers Development Co., Philadelphia.

air-cooled engines were having the same difficulty in securing recognition. It is most gratifying to know that 17 out of the 18 entries this year in the big race for the King's Cup on the other side had air-cooled radial engines.

We should not be thought backward simply because, at a certain period of airplane development, that particular type of engine was not in the fully developed stage. When airplane builders are ready for us to build the engines, we are ready to do so. That is one reason that I want to get an anticipation of the next move in engine design for the light airplane. What size is it to be? Many say it is to be the 60-hp. engine. If that is wanted, we will get busy on it; we are waiting for the word.

One of the problems with the radial-engine design was the elliptical path that is taken by the small pins on the subsidiary rods. Objection was made that the major axis of the ellipse did not coincide with the center-line of the cylinder, which resulted in certain peculiarities and the maximum error of 12 deg. in the ignition timing. Personally, I do not think it matters much, but I should like to know whether or not it is common practice now to compensate for that slight error. I know that some do not compensate for a 12-deg. difference.

A fine picture of a bearing was shown on the screen. Will Mr. Mead tell us something about the technical detail, upon which, to a great extent, depends the success or failure of the fixed radial engine? That bearing, of course, is very heavily loaded, and Mr. Mead did not tell us of the grief his company has gone through in constructing a bearing that would stand-up to the work. There are several expedients; one is to counterbalance and another is to use different kinds of material. Some engineers put their faith in steel bushings. I should like to have Mr. Mead tell us what is best for that bearing surface and how it is retained.

I should also like to hear something about the cooling of the oil used in the engine, which is a very important detail, because I do not believe that the present system of oil-cooling, in which oil passes through a radiator having tubes running through it, is an efficient way of removing the heat from the oil.

Solution of Big-End-Bearing Problem

George J. Mead:—We do not compensate for the slight error mentioned; it made an impossible sort of magneto. This could be avoided by using battery ignition. Our solution of the problem on the connecting-rod big-end bearing was a case, I think, of "where ignorance is bliss, 'tis folly to be wise." We had expected considerable trouble with these bearings, probably due in large part to rumors from Europe and to many papers that came across illustrating the terrific loads and stresses involved. As a result, however, we tried to keep these bearings of reasonable size. The diameter of the crankpins, being small, keeps the velocity down, although this was not intentional, but a result of using the minimum knuckle-pin circle-diameter. We use oil freely for cooling the big-end and pistons. Until recently we have used successfully bronze babbitt-lined bearings. We are now using Allison steel-backed babbitt-lined bearings and they stand-up very well, so far as our experience with them goes. In the radial engine, where we have very rigid big-ends, the tendency to distort the bearing shells, which are inherently flexible, and thereby disintegrate the babbitt is eliminated. This flexibility has caused most of our babbitt failures, I believe, in the past.

For the oil-cooling we have used small air-cooled coolers on the side of the fuselage. Our main trouble has been to keep the engines and oil warm enough, especially at altitude. To this end we have even carried the covering of the fuselage up around the cylinders to reduce the cooling and also to provide a good streamline nose. Even with the cooling thus reduced, the pilots reported that they could not keep the engines hot, no matter what they did, above 14,000 ft. Therefore, we feel that an oil-cooler is unnecessary under ordinary conditions; perhaps it should be used in tropical countries. From investigation of some of the older types of air-cooled radial engine, I am inclined to believe that considerable oil-cooling was necessary to dissipate the considerable quantity of heat generated owing to poor design.

In propeller efficiency we have reached a stage of rather poor relation between the airplane and the propeller speed, in some cases. In the slow-speed or 100-m.p.h. ships it is not usually efficient to turn the propeller above 1500 r.p.m. This angle of the problem will lead us, I am sure, to the use of geared engines for weight-carrying ships. We have avoided gears for years and have not really investigated their merits. Mr. Crane has advocated the use of gearing many times. Lately the engineering division at McCook Field began to realize that geared engines are important as they provide a means for increasing airplane performance.

John H. Geisse[5]:—I suggest that engines be built for endurance at full power or else that their full power be decreased to a point where the engine will give satisfactory operation. The English now state definitely that the rated power shall be approximately 97 per cent of the maximum power. If we use a low rating it is likely to lead to two abuses. One of these is that, if the engine is capable of developing about 350 hp. and we rate it at 300 hp., an engine that is in poor condition and develops only 300 hp. can still pass an acceptance test, although we know something is wrong with it. The other is that we cannot keep our pilots from taking out of the engine all the power they can get. It may be called a 300-hp. engine but they will fly it at 350 hp., and it was designed for 350 hp.

Mr. Mead:—I thoroughly agree with Mr. Geisse that the power ratings must be tempered with good judgment, and that the general inclination today is to overrate the powerplants. This problem is made especially difficult because it involves the use of unknown quantities in fuel. For example, the British gasoline contains the equivalent of approximately 20 per cent of benzol, which allows a higher rating than is permitted by our Eastern gasoline. It is impossible to develop a rating based on an arbitrary value for mean effective pressure, as certain designs are capable of running without detonation at a considerably higher mean effective pressure than are others.

Reliability Most Important in Commercial Work

Edward P. Warner[6]:—As Mr. Mead has pointed out, the importance of the basic weight of a powerplant in the design of aircraft varies with the length of flight for which those aircraft are being planned, and on a long trip the consumption of fuel may far overshadow small differences in the weight of the engine itself and its accessories. It is no less true that the importance of engine weight varies with the service for which the airplane is planned, even though the length of flight remains constant, and that this importance increases in measure as the useful load, other than fuel, per unit of power

[5] S.M.S.A.E.—Senior engineer, aeronautical engineering laboratory, Naval Aircraft Factory, Philadelphia.

[6] M.S.A.E.—Professor of aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

diminishes. In a pursuit airplane, for example, in which the load is fixed by military requirements at a virtually irreducible figure, any increase of engine weight or of frontal area means an immediate reduction in performance, with a consequent decrease in fighting efficiency, which cannot be made up at any other point.

On a commercial machine, the same increase in engine weight would involve simply a reduction in pay load without change of performance, and it might easily bring in its train advantages in economy of operation or in reliability that would more than counterbalance the effect on net income of the reduction of the load carried. A typical commercial machine may be expected to carry a pay load of at least 4 lb. per hp. with existing engines. An increase of 1 lb. per hp. in engine weight, or approximately 50 per cent, would then involve a reduction of only 25 per cent in pay load, and it is at least conceivable that the increase in reliability which would result would be of such value, especially in passenger service, that rates could be increased to a point which would keep the gross return with the heavy engine the same as with the light one.

Reliability must be insisted upon for commercial service. An average of one mechanical forced-landing every 100 or 200 hr., which figures are common in commercial services at present, is far too high. To compete with existing means of transport by land and sea, the commercial airplane must present a record of reliability at least comparable with those other means of transport at all seasons of the year. That requires not only improved methods of navigation but a freedom from forced-landing hazard, to secure which both the use of multiple engines and improvement of the dependability of each single engine must be invoked. Over-all efficiency, measured by the ratio of propeller thrust to engine weight, which ratio depends, of course, on the speed of flight of the airplane in any case, is of relatively minor importance in powerplants for commercial flying. Reliability must receive first consideration, with no other requirement more than a very distant second in importance.

Can Sacrifice Lightness for Fuel Economy

C. F. Taylor[1]:—Mr. Mead's paper is interesting as a catalog of present types and tendencies in aircraft engines but is a striking reminder of how little *fundamental* progress has been made in this field. Essentially, the gasoline engine has not changed since the days of Mr. Otto, and the newer aircraft engines remind one strongly of those used in the early years of heavier-than-air flying. The progress that has been made is almost entirely in the nature of refinement of detail. I am afraid that, in our enthusiasm for immediate practical results, we have neglected the more fundamental research work that might by this time have evolved types of even greater practical value than the present ones. In the field of true research we are considerably behind some of the European countries.

The statement that we could well afford to add weight to an engine if it would save something in fuel consumption, is worthy of further consideration. The American aircraft-engine designers, and purchasers particularly, always have been too enthusiastic about obtaining the maximum power from an engine even at the expense of economy. That much better economies can be obtained was illustrated by the German B. M. W. engine that appeared in 1918. In this engine, the maximum power-output had been deliberately sacrificed to obtain high fuel-economy. This was done simply by providing the engine with a high compression-ratio, small and well-heated inlet-manifolds and a carbureter designed to run partially throttled for sea-level operation. Except at sea level, the sacrifice in power was small, since the carbureter throttles could be opened further as the altitude increased. This same thing can be done with any modern aeronautical engine, but the designers and purchasers have so far been absolutely unwilling to make the small sacrifice in maximum power-output necessary to incorporate these features. The saving in fuel made possible by these simple expedients may be as high as 20 per cent.

In the consideration of weight to be carried, oil consumption is of relatively minor importance, since the quantity of oil to be carried is always very small in proportion to the weight of the fuel and engine. In a well-designed engine, the rate of oil consumption never exceeds 10 per cent of the fuel consumption. While a low oil-consumption is obviously desirable, it should never be obtained at a sacrifice of lubrication. Some of the very low oil-consumptions of certain aviation engines, which have been reported recently, lead to the suspicion that the lubrication of the pistons and cylinder-walls of these engines may be inadequate.

Air-Cooled Engines Limited by Radiation Surface

The advantages of air-cooling, particularly in regard to simplicity and reliability of the powerplant, are obvious. Nevertheless, I cannot agree with some recent statements that the air-cooled engine is about to replace the water-cooled engine for all aeronautic purposes. To cite an obvious instance, on those aircraft in which maximum speed is the principal requirement it would seem that the water-cooled engine, with wing-skin radiators, always will have the advantage over the air-cooled engine. Looking into the matter a little farther, it is apparent that the amount of surface available for efficient heat-dissipation is strictly limited in the case of the air-cooled cylinder, whereas, in the case of the water-cooled cylinder, the radiation surface can be increased almost indefinitely. With this in mind, it seems reasonable to question whether the number of cycles per unit of time will not be limited in the case of the air-cooled cylinder by the capacity of the cooling surface to dissipate heat. This may impose a limit on the speed of the air-cooled engine lower than the limiting speed of the corresponding water-cooled type. In this connection, it seems that one of the promising fields for improvement in the aircraft engine is the increase in power output per unit of weight and piston displacement to be obtained by increasing the rotational speed of the crankshaft. The possibilities along this line have been well illustrated in the field of racing automobiles. I am not aware that any air-cooled cylinder of aircraft size has demonstrated an ability to maintain such high brake mean effective pressures at high speeds as have been demonstrated by certain recent water-cooled aircraft-engines. When the limited cooling surface of the air-cooled cylinder is considered in connection with high-altitude supercharging, a further limitation is indicated which may keep the water-cooled engine in the field for some time, especially for military purposes.

It is fully admitted that the present tendency toward air-cooled powerplants for aircraft is sound, and that the majority of aircraft engines built, at least in the immediate future, will be of the air-cooled type.

Objections to Large Radial Engines

Regarding the form of the engine, I seriously question whether the radial type will hold its own, except in the

[1] M.S.A.E.—Chief powerplant engineer, Wright Aeronautical Corporation, Paterson, N. J.

smaller sizes. The outstanding advantage of the radial type is the ease with which it can be inspected and overhauled while installed in an airplane. This, together with a slightly lower weight per cubic inch of displacement and a possible slight saving in cost of construction, appears to be the principal advantage of this type. On the other hand, the radial arrangement gives the largest head-resistance area of any of the usual arrangements of cylinders, and this becomes a very serious objection when the engine is large in comparison with the cross-section of the fuselage. The maximum possible crankshaft-speed of the radial type always will be less than that of types in which fewer cylinders operate on each crankpin, and this limitation in speed constitutes a very serious objection where high output per unit of weight and piston displacement is desired. High crankshaft-speed does not necessarily involve high propeller-speed, since thoroughly reliable propeller reduction-gears are available at an increase of approximately 10 per cent over the dry weight of the direct-drive engine. On the other hand, it has been demonstrated recently that the V-type air-cooled engine is entirely practicable and can have as good cylinder-cooling as the radial type. A logical conclusion from these considerations is that the radial engine will hold its own in the relatively small sizes, particularly for commercial and training purposes, for which low cost and ease of overhaul and maintenance are primary considerations. In the larger sizes, however, and where high performance of airplane and engine is desired for a given weight and displacement, it is probable that the V and X-types of air-cooled engine will supersede the radial type.

MR. MEAD:—Undoubtedly considerable advances can be made in the development of aircraft engines through more extensive research. On the other hand, this is particularly expensive, and now that the aircraft industry is barely able to make a living it is out of the question for most companies to consider pure research. As in other lines of endeavor, this will be forthcoming when the industry becomes profitable. In the meantime, the Government is carrying on certain problems in pure research, so that this field cannot be regarded as being entirely neglected.

I agree fully with Mr. Taylor that the oil consumption on certain engines has been too low, which has resulted in wear and other difficulties. This has come about through a laudable endeavor to reduce the oil consumption. When it is considered how little oil is used, even though it is several times the consumption that has recently been secured, it is obvious that a reduction of this item is not important and is likely to be dangerous. We may some day reach a stage in air-cooled-engine development when the power output will be limited by the amount of cooling available on the cylinders themselves. However, from the tests that have been made to date, it is obvious that there is a considerable factor of safety in the cooling now available with fins placed directly on the cylinders, even at high altitudes and when a supercharger is employed. Except perhaps for racing, the flight tests that have recently been made show that there is little or no difference in the performance of an airplane equipped with an air-cooled or water-cooled engine of similar power. As a matter of fact, so far airplane performance has been improved by the use of air-cooled engines. Obviously, the radial engine itself is larger than the V-type water-cooled engine from a head-resistance standpoint. On the other hand, it seems that the resistance of the exposed parts of the radial engine is no more than that of the water radiator and exposed parts of the water-cooled engine.

THE AUTOMOTIVE INDUSTRY

SINCE the outbreak of the world war, an upset has taken place in the industrial leadership in America which is fully as surprising as the political changes that have occurred in Europe during the same period. The industrial change has come quietly. An industry that for years held undisputed sway as America's greatest has been dethroned from its leadership and relegated to third place. Another industry that in 1914 had all it could do to hold eighth place in the race of America's big 10 has quietly but relentlessly overtaken, one by one, each of those then ahead of it, until now it is in the prized position of leader. The relative positions of the 10 leading industries of the United States in 1923 and 1914 is given in the accompanying table, the figures being based on the Government census of manufacturers for these 2 years.

The old king of industries, in America, was the meat packing and slaughtering industry. For years it ranked first in total annual wholesale value of its products. Today the new king is the automotive industry, an industry that 30 years ago was non-existent.

Political supremacy, as determined by warfare, depends on the elimination or subjection of one's enemies. Industrial supremacy, in America, depends evidently upon the elimination of wastes and the subjection of cost of manufacture. For the new king of industries in our Country has demonstrated itself to be the most efficient industry in the world. The efficiency of the automotive industry has been demonstrated thoroughly by the fact that automobiles cost 29 per cent less than before the war, while most other commodities cost from 40 to 80 per cent more. This means that tremendous steps must have been taken by the management of that industry in the reduction of both manufacturing and marketing costs.—*Industrial Management.*

THE 10 LEADING INDUSTRIES OF THE UNITED STATES IN 1923 AND 1914

	1923		1914	
Industry	Wholesale Value	Position	Wholesale Value	Position
Motor Vehicles	$3,163,327,874	1	$458,957,843	8
Steel Works and Rolling Mills	3,154,324,671	2	918,665,000	4
Slaughtering and Meat Packing	2,585,803,888	3	1,673,979,000	1
Foundry and Machine Shop Products	2,337,807,997	4	1,373,309,000	2
Cotton Goods	1,901,125,703	5	701,301,000	6
Petroleum Refining	1,793,700,087	6	396,361,000	9
Lumber and Timber Products	1,494,259,321	7	1,119,348,000	3
Electrical Machinery, Apparatus and Supplies	1,293,001,751	8	335,170,000	10
Printing and Publishing	1,268,501,566	9	901,535,000	5
Bread and Other Bakery Products	1,122,834,099	10	491,893,000	7

Balloon Tires for Use with Drop-Center Rims

By B. J. LEMON[1]

SEMI-ANNUAL MEETING PAPER *Illustrated with* PHOTOGRAPHS AND DRAWINGS

ABSTRACT

BALLOON tires for drop-center rims will further complicate the present muddled balloon-tire wheel-and-rim situation. The complications for the tire industry will be less than those for the wheel and the rim industries. Drop-center tires and rims with detachable wheels are the vogue in Great Britain; the movement is spreading to Continental Europe and is felt in America. British practice in tire construction has abandoned the "catch" bead; in rim dimensions, it has adopted the flange height and width of American flat-base rims. This is a step toward international rim-standardization. British tire diameters are trending toward 19 and 21-in. sizes. An apparent tendency exists to reduce the well-depth in drop-center rims. Medium-pressure tires are obtainable by such British builders of heavy automobiles as are not satisfied with the larger and more flexible balloon-tires.

The drop-center rim first came into use in America for the airplane, on which this rim is now standard. The Ford steel-spoke wheel with 4.40-in. drop-center tire and rim is the only American development to reach the commercial stage. A combination 4.40-in. casing and tube are obtainable commercially that will fit both 3½-in. flat-base and 4.40-in. drop-center rims. By convexing the well-slopes of the drop-center rim inward, more satisfactory conditions for proper seating of tire beads on rim bead-ledges are obtained. To render visible this bead seating a red guide-line is placed above the rim flange on the outside of the 4.40-in. drop-center casing. Such advantages and disadvantages as are now apparent are listed for 4.40-in. drop-center tires and rims. Instructions are given for the applying and dismounting of 4.40-in. tires on drop-center rims.

Development in America of wheels, rims and tires in sizes larger than 4.40 in. on the drop-center principle has been half-hearted. Results thus far with larger tires on drop-center rims are inconclusive. Two American wheels with drop-center rims are described. The apparent need for a straight-side tire and rim for motorcycles, perhaps of drop-center type, is imperative. The question of preference by the American motorist and car builder for a demountable-type rim, the degree of success of the Ford drop-center venture and the influence of export demands are cited as bearing heavily on the permanency of success of the drop-center tire and rim in America.

OF all human ambitions, an open mind eagerly expectant of new discoveries and ready to mold convictions in the light of added facts is the most difficult to achieve. In undertaking this paper on balloon tires and drop-center rims, the purpose is to present so far as available the best that has been thought and done on this problem and, through such presentation, to turn a stream of fresh and unbiased opinion on our stock notions of such tires and rims.

The balloon tire is now beginning its fourth year of service, during which period it has been adopted almost universally as standard equipment on American-built cars. As yet, no one appears to have attempted seriously to define this new tire. It is recognized as being a larger, more flexible casing to be run at reduced inflations. How long it will retain these characteristics is questionable, in view of the present downward trend of sizes of tire used as original equipment, which trend must of necessity mean an upward movement of inflation-pressures.

The designation of balloon-tire sectional measurements by decimals has been about the only permanent feature of the development. The number of plies in tires has varied, heights that were standardized for the 21-in. rim now range from 19 to 23 in. inclusive, and the number of sectional sizes including major construction-variations equals half the number of makes of American-built cars. Meanwhile, American automobile and tire industries are likely to face another venture in the shape of balloon tires for drop-center rims.

BRITISH VERSUS AMERICAN MADE RIMS AND TIRES

The great influx into Europe of American automobiles during the war demonstrated that the American straight-side cord-tire on the demountable rim gave mileages considerably in excess of those delivered by the European clincher fabric-tire. In spite of this mileage superiority, foreign tire-makers clung tenaciously to the clincher principle, even to the extent of developing a new line of clincher cord-tires. They also continued to oppose persistently the demountable rim and straight-side cord-tire. The serious objections to the demountable-type rim were due to some extent to unfavorable experience with loose or rusty locking-rings or to difficulty with collapsible rims of the transversely split type. Moreover, wood wheels largely used on American cars were little used abroad, being heavier and more costly than popular European detachable wheels with clincher rims.

RE-INTRODUCTION OF THE DROP-CENTER RIM

The drop-center rim for automobiles was not practicable until the flexible balloon-tire was produced. With the advent of the balloon tire in 1923, the Dunlop Company of England grasped the opportunity to re-introduce the drop-center rim in combination with the detachable wheel for balloon tires. This rim, designated "well-base" abroad and patented by C. K. Welch in 1890, had remained dormant so far as automobiles were concerned for sufficient time for the patents to expire. The rim was not only standard for bicycles in Europe, but was in considerable use on airplanes and motorcycles and, in the early days, had even been tried on automobiles.

The detachable wheel and drop-center-rim combination both met the weight and cost objections raised against wood wheels and demountable straight-side rims by European car builders, and also provided an easy tire-mounting which appealed to the car-owner. As a result of 3 years of drop-center tire-and-rim effort, 80 per cent

[1] M.S.A.E.—Automotive contact engineer, United States Rubber Co., New York City.

of new-model British-cars now carry straight-side balloon tires on detachable wheel drop-center rims. A list of these cars and of their tire equipment is given in Table 1.

British Drop-Center Rim-Sizes

The present British drop-center rim for automobile balloon-tires is made in four sizes, and for motorcycle balloon-tires in two sizes, as shown in Fig. 1. It is a one-piece unit having a circumferential well or sunken base, enabling a casing to be fitted or removed with considerable facility. This drop-center rim can be incorporated with any type of wheel and presents an appearance that appeals to the users, particularly of small cars. The rim flange is thick, hollow and invertedly rolled. The four sizes of automobile rim have the same flange heights and distances between flanges as those of the Society of Motor Manufacturers & Traders Provisional Standard No. 12 and also the same as those of the Society of Automotive Engineers straight-side rim-standards. The diameter of the bead-ledge of the British automobile drop-center rim is 1/16 in. greater than the diameter of the bead-seat of the American straight-side rim. This is to assure a tight fit when used on the drop-center rim and still allow easy mounting on the flat-base rim. No definite British standards have yet been established with reference to the shape or depth of the drop-center portion, because experimentation on this problem is still under way in both Great Britain and America.

TABLE 1—LIST OF BRITISH-BUILT CARS NOW TAKING BALLOON AND MEDIUM-PRESSURE TIRE-EQUIPMENT AND SIZES

Tire Size, In.	Rim Size, In.	
26 x 3.50	3 x 19	Austin
27 x 4.40	3½ x 19	A. C. Cars, Ariel, B. S. A., Bayliss Thomas, Calcott, Calthorpe, Cluley, Clyno, G. W. K. G. N., Galloway, Gnome, Gwynne, Humber, Invicta, Jewel, Jowett, Lea & Francis, Morris, Napier, Rhode, Riley, Rover, Singer, Standard, Swift, Wolseley
28 x 4.95	3½ x 19	A. C. Cars, Argyll, B. S. A., Bean, Calthorpe, Galloway, Hampton, Hillman, Horstman, Lagonda, Morris, Standard, Straker Squire, Talbot, Triumph, Vulcan, Whitlock, Windsor, Wolseley
29 x 4.40	3½ x 21	Ford
29 x 4.95	4 x 20	Alvis, Armstrong-Siddeley, Arrol-Johnston, Calcott, Galloway, Riley
30 x 4.75	3½ x 21	Hillman
30 x 5.25	4 x 20	Arrol-Johnston, Calcott, Cluley, Crossley, Cunitt, Morris, Talbot
31 x 5.25	4 x 21	Armstrong-Siddeley, Austin, B. S. A., Bean, Daimler, Dunalastair, Monarch, Rover, Singer, Standard, Star, Swift, Triumph, Vauxhall, Waverley, Whitlock, Wolseley
32 x 5.25	4 x 22	Rover, Vauxhall
33 x 6.00	4½ x 21	Arrol-Johnston, Aster, Austin, Bean, Beardmore, Bentley, Daimler, Rolls Royce, Sunbeam, Wolseley
33 x 6.75	5 x 21	Bentley, Daimler, Napier, Rolls Royce, Vauxhall, Vulcan
35 x 6.75	5 x 23	Daimler
37 x 7.30	6 x 23	Daimler
4¾ for 21	4 x 21	Austin, Crossley, Humber
5¼ for 21	4½ x 21	Austin, Humber, Lanchester, Star
6 for 21	5 x 21	Bentley, Lanchester, Sunbeam

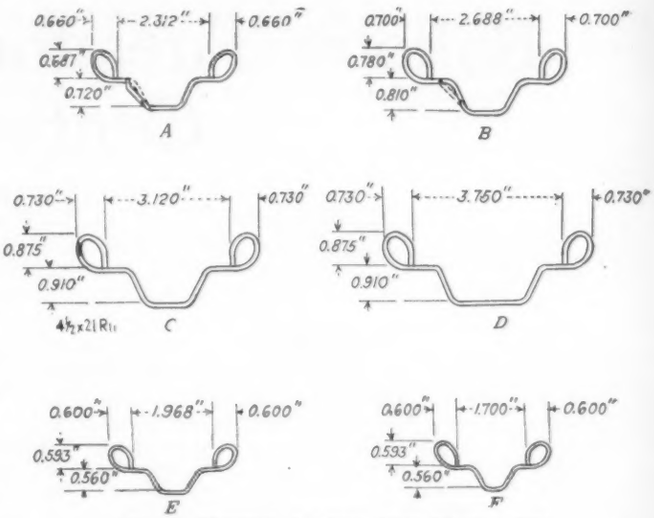

FIG. 1—PRESENT BRITISH DROP-CENTER RIM

For Automobile Balloon-Tires It Is Made in Four Sizes A-D and for Motorcycle Balloon-Tires, in Two Sizes E and F. This Rim is a One-Piece Unit Having a Circumferential Well or Sunken Base, Enabling a Casing To Be Fitted or Removed with Considerable Facility

Data on the Rim and Tire Sizes and the Rim Weights Are Given Below

Type of Rim	Size of Rim	Size of Tire	Weight of Rim, Lb.	Oz.
A	3½ x 19	4.40 x 27	9	10
		4.95 x 28	9	10
	3½ x 21	4.40 x 29	10	10
		4.75 x 30	10	10
B	4 x 21	4.75 x 30	12	12½
		5.25 x 31	12	12½
C	4½ x 21	5.25 x 31	15	6
		6.00 x 33	15	6
D	5 x 21	6.00 x 33	16	5
		6.75 x 33	16	5
E	3 x 19	3.50 & 4.00	5	6
	3 x 21	3.50 & 4.00	5	15
F	2½ x 19	3.00 & 3.50	5	2
	2½ x 21	3.00 & 3.50	5	10

British Wheels with Drop-Center Rims

Types of wheel in most extensive use in Britain are steel artillery, disc and wire, all of which are well adapted to take the drop-center rim. Wood wheels are used so seldom that the problem of taking care of wood-spoke heads with drop-center rims has received little attention. The steel artillery type wheel is most popular, comprising perhaps 50 per cent of the equipment in use, while the disc wheel and the wire wheel each represent about one-quarter of the wheels in use. Although the steel artillery-type wheel predominates, no absolute unanimity exists among British manufacturers regarding this question; but appears to be a common acceptance of the drop-center rim.

From the British viewpoint, the weight and the cost factors of drop-center-rim wheels have decided advantages over demountable-rim wheels. Table 2 is a comparison by weight of three wheels with different rim-types marketed by the same British wheel-manufacturer, as well as a statement of the present cost to the car builder in like quantities, indicating the cost advantage in Great Britain of the drop-center wheel.

British Tires for Drop-Center Rims

The widespread use of balloon tires on drop-center rims in Great Britain is indicated in Table 3, which lists also for comparison the sizes of balloon tire and rim supplied by American automobile companies as original equipment on present-model American-cars.

The adaptation of the British straight-side balloon-tire to the drop-center rim presented no difficult problems in tire construction. Tires, to be satisfactory on this new rim obviously required, to prevent tube pinch-

ing, a narrow bead-base that did not overhang the bead-ledge. Moreover, too wide a bead could not be forced easily into the drop-center portion of the rim during tire application and removal.

Early British tires for drop-center rims carried on the outside of the casing and above the bead a "catch"-bead or cushion of rubber that conformed to and rested upon the inturned rim-flange, as shown in Fig. 2. The intended purpose of this catch-bead was to protect the side wall by holding the beads on the rim ledge when the tire was run deflated. This catch-bead has been discarded now, not only because it appears unnecessary for the purpose but because undoubtedly it interferes with the natural bending of the tire during service and also with easy mounting on drop-center rims.

TABLE 2—WEIGHT AND COST COMPARISONS OF BRITISH WHEELS HAVING DIFFERENT RIMS

Steel Artillery-Wheel Having Rim	Size, In.	Weight, Lb.	Approximate Cost
Clincher	32.28 x 4.72 (820 x 120 mm.)	14.75	$7.00
Flat-Base Straight-Side	43 x 4½	26.50	9.44
Drop-Center	33 x 6	16.00	4.96

To avoid conveying an erroneous impression by listing in Table 3 only balloon-tire sizes as representative of British practice, it should be kept in mind that a few British builders of heavy cars did not and, in fact, do not receive the balloon tires as favorably as do builders of light cars. Early reservation of this sort was noticeable also in America.

The longer chassis, the better spring-suspension and the more comfortable seat-cushions designed into the larger cars provide many of the riding-qualities that the balloon tire gives to the light car. In the case of heavier cars, steering difficulties were more noticeable, shimmy vibrations were more difficult to handle and roll, or sway, at high speeds was more objectionable.

TABLE 3—BALLOON TIRES AND DROP-CENTER RIMS NOW USED IN GREAT BRITAIN AND AMERICA

British Balloon-Tire Sizes, In.	Drop-Center-Rim Sizes, In.	American Balloon-Tire Sizes, In.	Flat-Base Wheel Rim Sizes, In.	Sizes, In.
25 x 3.00	2½ x 19	—	—	—
26 x 3.50	3 x 19	—	—	—
27 x 4.00	3 x 19	—	—	—
27 x 4.40[a]	3½ x 19	27 x 4.40	26 x 3½	19
29 x 4.40[a]	3½ x 21	29 x 4.40[b]	28 x 3½, 4.40	21[c]
30 x 4.40	3½ x 22	—	—	—
—	—	29 x 4.75[b]	28 x 4	20
30 x 4.75[a]	3½ x 21	30 x 4.75[b]	28 x 3½	21
28 x 4.95[a]	3½ x 19	—	—	—
29 x 4.95	4 x 20	29 x 4.95	28 x 4	20
30 x 4.95	4 x 21	30 x 4.95	28x3½ 29x4	21
31 x 4.95	4 x 22	—	—	—
30 x 5.25	4 x 20	30 x 5.25[b]	28 x 4	20
31 x 5.25[a]	4 x 21	31 x 5.25[b]	29x4 30x4½	21
32 x 5.25	4 x 22	—	—	—
30 x 5.77	4½ x 20	30 x 5.77[b]	29 x 4½	20
32 x 5.77	4½ x 22	32 x 5.77	31 x 4½	22
—	—	33 x 5.77	32 x 4½	23
—	—	32 x 6.00[b]	28x4 29x4½	20
33 x 6.00[a]	4½ x 21	33 x 6.00[b]	30 x 4½	21
—	—	33 x 6.20	30x4½ 31x5	21
32 x 6.20	4½ x 20	32 x 6.20[b]	28x4 29x4½ 30x5	20
—	—	32 x 6.75[b]	29x4½ 30x5	20
33 x 6.75[a]	5 x 21	33 x 6.75[b]	30x4½ 31x5 33x6	21
34 x 7.30	5 x 20	34 x 7.30	30 x 5	20

[a] Indicates tires to be considered standard on 19 and 21-in. wheels for all new British cars taking balloon tires.
[b] Indicates sizes of balloon tires most used in America.
[c] Indicates drop-center rim.

FIG. 2—TYPE OF BRITISH BEAD-CONSTRUCTION FOR DROP-CENTER RIMS Showing the Old Type at the Left and the New Type at the Right, the "Catch" Bead on the Former Type Having Now Become Obsolete

Builders of most of the more expensive types of automobile generally display hesitation in adopting rather extreme innovations. The balloon tire is a radical change. When confronted with a demand for a radical change, the more conservative producer or engineer does not alter his mind quickly either as the result of logic or refutation. As he learns more about the problem, his ground gradually shifts from under him so that he no longer looks at things as he formerly did. His about face, unless it be of absolute necessity, is not the one-step turn of the drill ground but is a gradual slowing-down, a turning by small segments, and then a speeding-up in the direction of the new idea.

BRITISH MEDIUM-PRESSURE TIRES

To meet present requirements of such conservative British car builders who feel that the larger balloon-tires are a bit too flabby, a line of medium-pressure tires in three sizes has been introduced in England and these are specified in Table 4. The medium-pressure tires are intermediate between the balloon and the corresponding high-pressure tires in size, weight, construction, and required inflation-pressures. They are interchangeable on the same rims, size for size, with the corresponding balloon tires and, to avoid confusion in denomination are, where possible, designated by fractions instead of decimals. They are made for 21-in. rims only.

TABLE 4—COMPARISON OF SIZES, LOADS AND INFLATION-PRESSURES OF BRITISH HIGH-PRESSURE, MEDIUM-PRESSURE AND BALLOON TIRES

Range of Wheel Load, lb.	675–1,120	1,000–1,500	1,400–1,900
High-Pressure Tires, in.	4	4½	5
Range of Inflation-Pressure, lb. per sq. in.	45–60	45–60	45–65
Medium-Pressure Tires, in.	4¾	5¼	6
Range of Inflation-Pressures, lb. per sq. in.	30–50	38–54	42–57
Balloon Tires, in.	5.25	6.00	6.75
Range of Inflation-Pressures, lb. per sq. in.	27–35	26–38	30–40

BRITISH TUBES FOR DROP-CENTER RIMS

British tire-practice is to supply specially molded oval-shaped tubes for use on drop-center rims. The inner circumference of such tubes, the part that goes into the well of the rim, is somewhat smaller than the corresponding inner-circumference of tubes made for flat-base rims. The deeper the well in the rim is, the smaller this inner circumference of the tube should be.

The valve in the British tube is inserted on the side of the tube, since it projects through the side of the

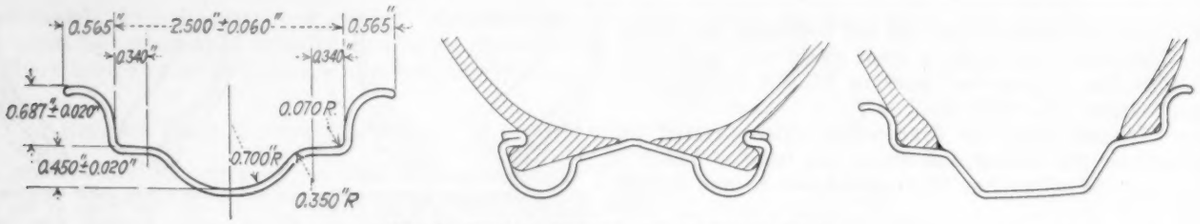

FIG. 3—TYPICAL BRITISH AND AMERICAN RIMS

The British Experimental 4.40-In. Drop-Center Rim with Shallow Semi-Circular Well Is Shown at the Left. The Central View Depicts the Palmer-Type Airplane-Rim Used on American Airplanes during the War. At the Right, the American Airplane Drop-Center Rim, Present Standard, Is Illustrated

drop-center rim. The standard valve for balloon-tire tubes on drop-center rims in Great Britain is Schrader No. 5464, which has the same barrel-diameter, 10 mm, (0.39 in.), as the American No. 777 valve, and is 1⅛ in. in length to the end of the large thread. Standard No. 777 valve-fittings are used with No. 4846 dust-cap, 1⅜ in. in length.

ADVANTAGES AND DISADVANTAGES FROM BRITISH VIEWPOINT

The drop-center rim is fitted easily to all types of detachable wheel. It has lightness and low cost and, in the case of small-size tires, permits easy mounting. The application feature particularly appeals to the British motorist who has once been a bicyclist, and there are several million drop-center-rim bicycles in use in Great Britain. It retains the advantages of the inextensible-bead straight-side tire and, at the same time, eliminates the demountable side-flange and transversely split rims decidedly objectionable to former clincher-rim advocates.

No major disadvantages are reported in the use of the drop-center rim in Great Britain. This may be due to the greater tolerance of British motorists long used to the clincher tire and rim. However, drawbacks considered minor abroad might be held of major proportions in America where the flat-base rim and straight-side tire have performed exceedingly well.

When first introduced, it was contended that the drop-center tire apparently so easy to fit would come off just as easily when run deflated. This expected disadvantage has not yet developed. It is true that both the smaller sizes of clincher and drop-center tires have been known to roll off when run at high speed around sharp turns; but, unless the beads of the drop-center tire are well down into the gutter when violent side-sway occurs, little likelihood appears that the straight-side tire can roll off the drop-center rim when deflated.

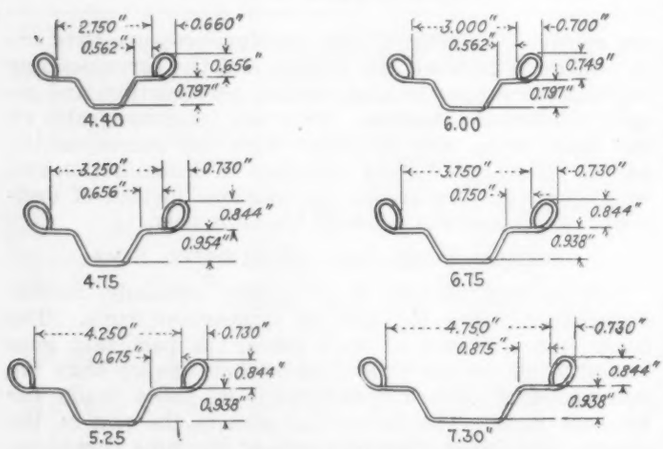

FIG. 4—EXPERIMENTAL DROP-CENTER RIMS

These Constitute the Standards Tentatively Adopted for Experimental Purposes by the Tire & Rim Association on Jan. 8, 1925

Advice from reliable sources shows that the drop-center rim is a fixture and not an experiment in Great Britain. It is not merely used as optional equipment. All British makers with but two outstanding exceptions use this type of rim as standard equipment, and one of these two will supply drop-center rims if desired. Every indication points to the fact that, as soon as existing stocks of wheels carrying other types of rim are exhausted, the drop-center type will be standard on all future British cars.

DEVELOPMENT TREND IN GREAT BRITAIN

Wheels of 19 and 21-in. diameters are favored and apparently will soon displace such 20, 22 and 23-in. wheels as are now in use. The final shape and depth of the drop-center portion has not been reached. Experiments are under way to test a rim with a more shallow well of a semi-circular shape shown at the left in Fig. 3. It is claimed that this rim can be made more easily and cheaply, that the tire beads seat more readily on inflation and that a normal round tube instead of the specially molded tube can be used. Apparently, the deeper the well is the easier it is to mount the tire. However, a very deep well may emphasize the chances of having the tire leave the rim on sudden deflation. It is suggested that, by properly ovalling the tire during application, easy fitting can be retained even on the experimental shallow-well rim.

Experiments are under way in Great Britain to utilize the drop-center rims with flexible large-size pneumatic-tires of the balloon type. If successful, considerable wheel-weight below the springs will be saved, flaps can be discontinued and ease of mounting will perhaps be facilitated.

Early British practice of making drop-center rims somewhat wider at the bead-seat than corresponding flat-base rims has been revised. Since present British drop-center rims are identical in most respects with the American flat-base straight-side rims, an opportunity for international standardization is afforded which should be given every possible consideration. British interests have taken an important step toward this standardization, to realize which is a big undertaking. Things that have size attract men who have size. Will American car and rim interests measure up to this opportunity?

DROP-CENTER TIRES AND RIMS IN AMERICA

The drop-center type of rim was nowhere used in America prior to the World War, so far as can be learned. In the war period and well into 1919, the airplane rim used in America was known as the Palmer type; it is shown in the central view of Fig. 3. This rim was adopted in December, 1917, as standard by the Society. During the latter years of the war, fairly extensive use was made by Europeans of the drop-center rim on airplanes.

The drop-center rim was proposed for adoption for

American airplanes early in 1920, in sizes from 3 to 12 in., and 36 x 8 in. rims were first made and tested at McCook Field. So well was this development received that on June 14, 1920, the Tire & Rim Association discussed the innovation with the recommendation that two additional sizes be made. After a further period of development, the drop-center rim was made standard on May 21, 1921, and different tire companies were asked to develop airplane tires for this rim. This type of rim is being used today and, with the present type of tire-bead construction, it is shown in Fig. 3 at the right.

Drop-Center Rims and Balloon Tires

Early in 1923, Colin Macbeth, representing the Dunlop Company of England, came to America to demonstrate the drop-center-rim principle for automobiles. As a result, various American rim-companies made drop-center rims in small quantities, and tentative standards were adopted by the Tire & Rim Association as shown in Fig. 4.

The slow development of drop-center tires and rims for

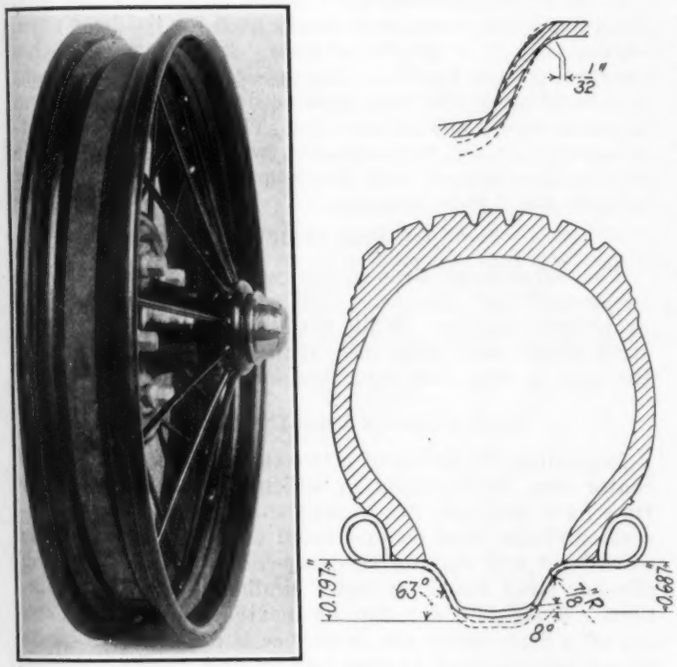

Fig. 5—Comparison of Rim Details
The Ford Steel-Spoke Wheel with Drop-Center Rim Is Shown at the Left. In the View at the Right, a Comparison Is Made between the Ford Rim and the Drop-Center Rim of the Tire & Rim Association, Being Illustrative of the Variations in the Sides and Base of the Well

American automobiles appears due to three main causes. First, because the flat-base rim with the straight-side tire has been in use for a comparatively short time only, particularly on light cars, and is considered a fairly economical and satisfactory combination. Second, because other problems of vehicle design and improvement, such as changes brought about by balloon tires and four-wheel brakes, appeared more pressing. Third, because but one outstanding American manufacturer has featured the mechanical or sales advantages of the drop-center tire-and-rim combination.

Steel-Spoke Wheel with Drop-Center Rim

The only drop-center wheel and rim commercially obtainable today anywhere in America is made and distributed by the Ford Motor Co. Fig. 5 shows at the left

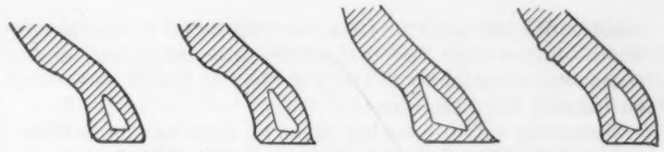

Fig. 6—Necessary Reshapement of Beads
In Regard to the Reshapement of Beads Required on American 4.40-In. Casings for Drop-Center Rims, Cable-Wire Beads for Flat-Base and for Drop-Center Rims Are Shown Respectively in the Left and the Left Central Views. Braided-Wire Beads for Flat-Base and for Drop-Center Rims Are Illustrated in the Right Central View and That at the Extreme Right

this wheel development. It is a detachable wheel with steel spokes butt-welded to the drop-center rim and to the hub. The rim differs from the Tire & Rim Association drop-center rim in certain respects as shown in the drawing at the right of Fig. 5. The main differences are in the slope of the well-sides, which is important, and the depth and shape of the rim bottom, which is comparatively unimportant.

The 4.40-in. Casing for the Steel-Spoke Wheel

The 4.40-in. balloon-tire for the steel-spoke drop-center wheel is now made to fit satisfactorily also on the standard flat-base 3½-in. straight-side rim. It is therefore called a *combination* casing. This combination feature is of considerable importance from the car-service and the tire-dealers' viewpoints for, as soon as it becomes widely produced by tire makers, it largely will remove the possibility of mounting on drop-center rims casings having a bead construction designed for the flat-base rim only. It also will eliminate the necessity of having dealers carry two lines of 4.40-in. casings if drop-center rims should come into widespread use. This combination casing, as it is now made, is properly tagged for dealer distribution and carries the following dealer instructions:

> This casing can be used on either a flat-base or drop-center rim
>
> Use the special flap when applying on flat-base rims
>
> Use the tube marked "for either flat-base or drop-center rim"

Essential modifications required in the standard 4.40-in. casing to accommodate it to the drop-center rim are a

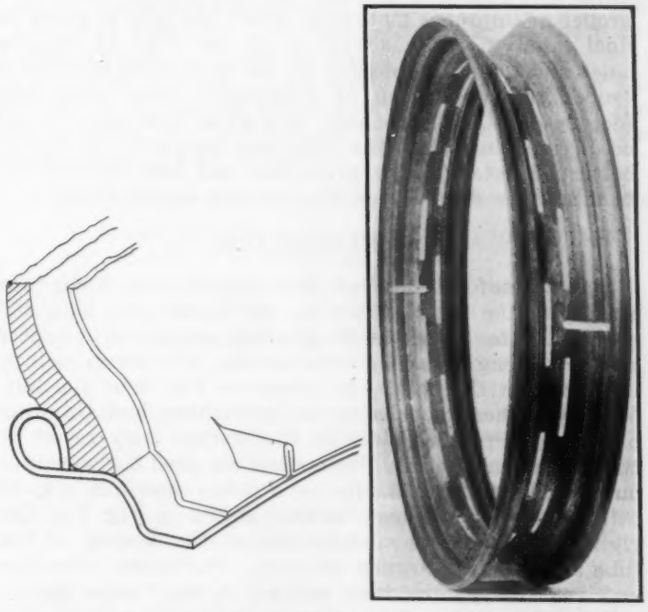

Fig. 7—Studies of Tube Buckle and Action during Inflation
Tube Buckle That May Result from Using a Tube Improperly Sized for the Drop-Center Rim Is Depicted at the Left. The View at the Right Illustrates the Slotted Drop-Center Rim That Was Used To Study the Action during Inflation of Tire Beads and Inner Tubes

bead-width not greater than the rim-ledge width, a soft-bead feather-edge toe to prevent tube pinching, and a somewhat snugger fit to the rim than is the fit of present casings on flat-base rims.

Since the soft-toe casing must be used on the flat-base rim, the length of the toe is important. If too long, the toe may double under and therefore bind during the act of applying or detaching the casing from the flat-base rim. The soft-toe must be compounded properly to resist fraying at the edge due to tire-stand abuse when the tire is applied by inexperienced persons.

The problem of bead-width is not a serious one where cable-wire bead-construction is used. With the braided-wire bead, however, greater construction-changes must be embodied to produce a bead-width satisfactory for the drop-center rim as indicated in Fig. 6. Should the bead be too wide and overhang the drop-center portion, tube difficulties will surely result at the toe of the bead. Moreover, wide beads cannot be forced so easily into the well on applying and removing the casing and are more likely to foul the tube during these operations or during inflation.

The narrow bead-ledge of the drop-center rim presents added bead-construction difficulties when, for example, a 4.75 or a 4.95-in. tire is used as oversize on a 4.40-in. rim. The beads of such oversize casings must be no wider than those of 4.40-in. casing.

Experience with casings mounted on the Tire & Rim Association experimental drop-center rim proved that the straight slope of the rim sides was unsatisfactory. Occasionally, a segment of one bead or of both beads would not climb all the way out of the drop-center portion, but would freeze against the rim at some point below the line of the bead-ledge. If left in this position, tube trouble would develop sooner or later. By modifying the angle of slope to an arc of a circle, this difficulty appears to have been overcome.

To assure that the beads on both sides will be seated properly on the ledges, a raised guide-line surmounted by a red stripe has been placed on the 4.40-in. combination-casing. This guide line and red stripe perform a very important function, for they provide visible proof of a proper or improper mounting before the tube is given its final inflation. The alteration of the slope of the rim sides and the red guide-line on the casing are believed to render the application of drop-center tires practically fool-proof. Unquestionably, this guide line can and will be discontinued when the American motorist has become better educated to the principles and best methods of handling the drop-center tire-and-rim combination.

The 4.40-In. Tube

The heretofore standard American 4.40-in. inner-tube used with the flat-base 3½-in. rim is both too long and sectionally too small to fit properly on the drop-center rim. Its length causes tube buckles at various points, especially at the splice, as shown in Fig. 7 at the left. Wherever these buckles occur, stretching and thinning of the rubber takes place so that failure may result at these weakened points. The method we used for working-out the proper fit of a tube on a drop-center rim was to utilize a slotted rim such as that shown in Fig. 7 at the right, which enables visualization of the seating of the tube at all points around the rim. Particular attention was required at the tube splice. A thick-edge heavy-splice will not blow-down into the well as readily as the remainder of the tube. Therefore, buckling is more likely to occur at both ends of such a heavy splice. A thin splice beveled at both ends is more satisfactory. Moreover, the small sectional diameter of the standard tube tends to prevent the tube as a whole from blowing evenly down into the drop-center portion, for the tube takes the path of least resistance, which is back into the casing rather than down into the rim. Because of difficulties of buckling and thinning, of failure of poorly proportioned or badly spliced tubes to blow-down into the rim and of improper seating of the tire-beads, tube pinching or failure has occurred in 4.40-in. casings carried only as spares. Fig. 8 depicts some possible causes of tube failure due to improper bead-seating.

By reducing the length of the tube and increasing the sectional or pole diameter, a satisfactory 4.40-in. tube called a *combination* tube has been developed for use on both 3½-in. flat-base and 4.40-in. drop-center rims. The combination tube is labeled: "For either drop-center or flat-base casings."

Flaps

No flap is required in the drop-center rim. However, since a combination casing will fit both flat-base and drop-center rims, a flap must be provided and properly marked for use with the combination casing on the flat-base rim. This flap is the same as formerly used for flat-base rims, except that it is slightly shorter. The reason for this shortening is to facilitate flap application and to prevent flap buckling or shifting when used with the shorter and larger section combination-tube. This flap functions satisfactorily on the flat-base rim, whether used with the combination tube or with the longer tube now generally sold for the 4.40-in. casing.

Rim Strip

The steel-spoke drop-center wheel is fitted with a fabric-and-fiber rim-strip that covers the base of the drop-center portion. While not absolutely necessary, this strip offers good assurance against possible fouling of the tube on rims that have been long in service.

Flat Tires on Drop-Center Rims

Regarding the action of a tire that goes flat on a drop-center rim, severe tests in which tires on drop-center rims have been run flat around sharp turns on dry concrete-surfaces have demonstrated that tires without the catch-bead will stay on the drop-center rim better than clincher tires would do under similar severe test-conditions. A possible way that an inextensible-bead tire can roll off a drop-center rim in service is to have both beads forced into the well at road contact and, at the same instant, to give the tire a violent lateral thrust. Tests indicate that this combination of conditions rarely develops on the road.

When a casing on the steel-spoke drop-center rim is run flat for any considerable distance, the tube may sometimes draw-down tightly into the well; in this position, its removal is effected best by first loosening and then pulling it out after one bead has been slipped over the flange. The inverted rolled-rim flanges of the steel-spoke wheel add strength, and have not been found to suffer damage or distortion by running on a deflated tire. Although the following statement is not yet proved, the rolled flange appears not so likely to injure the casing or tube as the present flange of the standard flat-base rim and is a great improvement over the clincher rim in this respect.

Steel-Spoke Drop-Center Wheel-and-Tire Advantages

Like other wire wheels, the steel-spoke drop-center wheel is detachable, a fifth wheel being used as a spare. It has the advantages of the detachable rim added to the

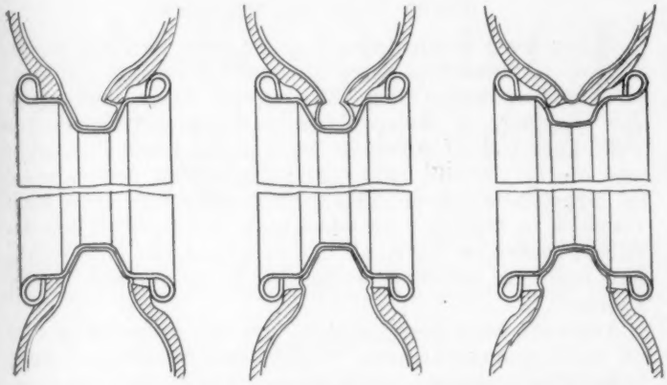

FIG. 8—POSSIBLE CAUSES OF BEAD FAILURE DUE TO IMPROPER BEAD-SETTING

Tube Failure Due to the Freezing of One Bead in the Rim Well Is Indicated at the Left, and Failure Due to the Freezing of Both Beads Is Shown in the Central View. In the View at the Right, the Curved Slope of the Rim Well Offers Less Chance for the Bead To Remain Frozen during Inflation

advantages of the detachable wheel and the light weight of the detachable wheel. In the event of tire trouble, the detachable fifth-wheel facilitates a quick tire-change. Should two tires be punctured, the drop-center rim offers a rather quick and comparatively easy means of detaching casing for tube replacement. Moreover, the bracket for the fifth wheel on the rear of the car is made sufficiently strong and is conveniently placed to function as a convenient tire-changing stand. Rim attachment-bolts, lugs and felloe band are eliminated. The fact that this drop-center rim is wider than the 3½-in. straight-side rim is considered by some an added advantage from the viewpoint of carrying capacity. (See Fig. 9.)

The detachable wheel should be received favorably by the export trade, particularly in those countries that either have not used or do not like flat-base demountable-rims or are already acquainted with the drop-center type of rim. When the tire is run flat, the tube and the valve-stem are protected better than is true with the flat-base rim.

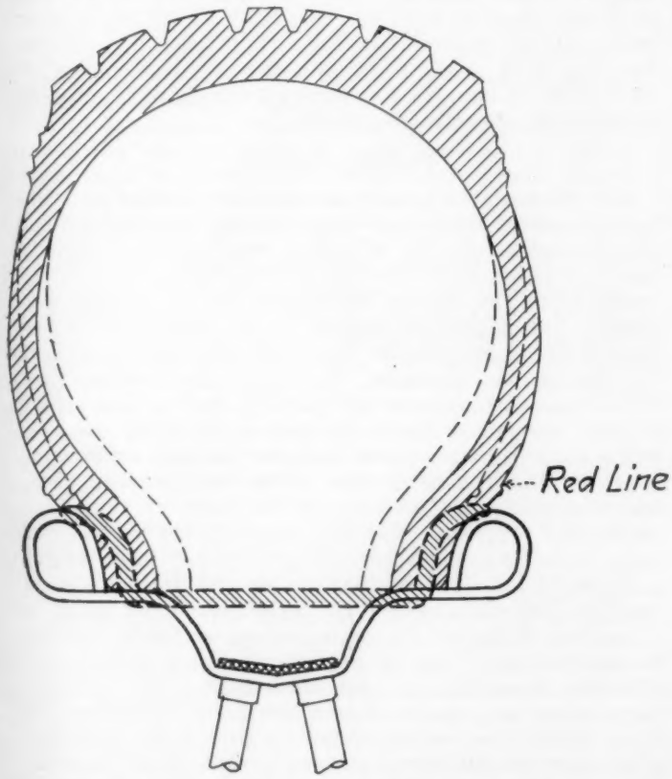

FIG. 9—FLAT-BASE AND DROP-CENTER RIMS COMPARED

The 4.40-In. Balloon Tire on a Flat-Base and on a Drop-Center Rim Are Illustrated. The Increase in Air Capacity on the Drop-Center Rim Is 13 Per Cent

STEEL-SPOKE DROP-CENTER WHEEL-AND-TIRE DISADVANTAGES

The American car-operator is entirely unfamiliar with the application to and removal of tires from drop-center rims. This disadvantage is minimized where the producer has a well-organized service-department and probably will become less important as the idea of the drop-center becomes more generally appreciated.

Possibilities of tube pinching exist, due to hasty or improper application of the casing and tube to the drop-center rim. Tube pinching from these sources would be analogous to trouble from improper flap-assembly on flat-base rims. Persistent efforts to educate the car-owner and the tire service-man have done much to reduce tube pinching through wrong size or improperly mounted flaps. There are also present apparent field-service difficulties of repairing the welded steel-spokes in the wheel when breaks or distortion occur. Tube difficulty may arise from attempts to use a flap on the drop-center rim or to use a tube not properly proportioned for this rim. Rims must not be oversized or improper bead-seating may result in tube difficulty.

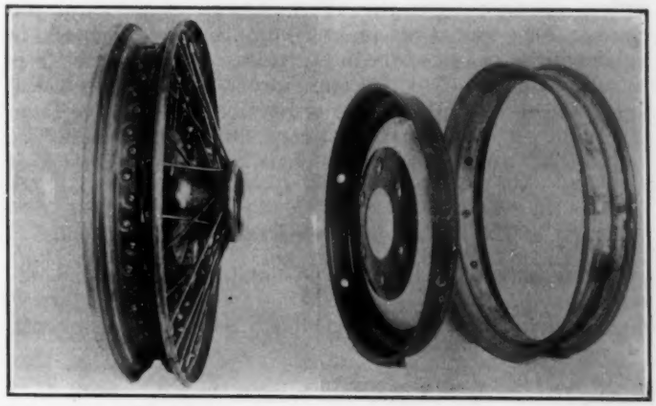

FIG. 10—WIRE WHEELS AND DISC WHEELS WITH DROP-CENTER RIMS

The Ash Wire-Wheel Is Shown at the Left, and the Baker Disc-Wheel and Demountable Drop-Center Rim Appears at the Right

APPLICATION OF A 4.40-IN. TIRE ON A DROP-CENTER RIM

(1) Insert the tube in the casing when inflated sufficiently to fit the casing loosely

(2) Place the tire on the rim, inserting the valve-stem into the hole at the top of the rim

(3) Push up on the valve-stem and press the sides of the tire together at the top, forcing both beads into the bottom of the drop-center portion

(4) Continue this action around the tire until the top half is resting in the drop-center portion

(5) Push the bottom half of the tire over the rim flange

(6) Before inflating, lift the bottom of the tire to allow the casing beads to seat properly on the rim

(7) Make certain that the casing is in proper position, with the red guide-line showing an even distance from the rim all around on both sides of the tire

(8) Apply and tighten the rim nut, then inflate the tire

(9) Use only casings having a red guide-line and tubes

marked: "For either drop-center or flat-base rims"

To Remove a Tire from a Drop-Center Rim

(1) Release sufficient air from the tube to allow the beads in the top half of the tire to be forced into the drop-center portion of the rim
(2) Remove the rim from the valve-stem
(3) Press the sides of the tire together, forcing both beads into the bottom of the drop-center portion
(4) Pull the bottom half of the tire over the rim flange, which will release the tire from the rim
(5) Application and removal of the casing are facilitated if the use of force is not attempted. Straight-side tire-beads, unlike clincher tire-beads, are inextensible. A small thin tool may be used, never a thick one; but such a tool is not essential. Unless care is exercised, the soft bead-toe will be injured by a tool

The British method of fitting a drop-center casing differs slightly from the above American recommendations. This variation is attributable to differences in valve length and location in the tube. British practice is to apply one bead to the rim, insert the tube and then apply the second bead. The projection of the valve from the side of the British drop-center rim makes it "getatable," regardless of the position in which the wheel comes to rest.

Drop-Center Rims for Tires Larger Than 4.40 In.

So far as can be learned, no outstanding finished development has taken place in America using tires larger than 4.40 in. on drop-center rims. Several experiments are now under way.

Ash Wire-Wheel

The Ash wire-wheel, shown at the left of Fig. 10, having a drop-center rim, has been under test for about 1 year. This wheel is designed to interchange with the present wood-wheel tread-spacing to allow proper load-distribution on axle bearings. The balanced spoke-lacing results in equal tension and strain on each spoke. The valve-stem is located in the side of the rim well. The rim is offset inward more than appears possible with many wood and disc wheels, thus providing clearance for brake construction. The brake-drum is largely within the plane of the tire ground-contact, thus minimizing the effect of braking strains on steering. Ash wheels with drop-center rim carrying 33 x 6-in. soft-toe-bead tires have run upward of 13,000 miles with no reported tire trouble.

Baker Disc-Wheel and Demountable Drop-Center Rim

The Baker disc-wheel with drop-center rim is shown at the right in Fig. 10. This wheel carries a drop-center rim that is transversely split at the valve hole. Small driving lugs are welded to the rim, fitting into holes in the felloe. When the tire is inflated, the air-pressure against the rim constricts the rim circumferentially, closes up the split and holds the rim tightly against the wheel. On no occasion has the rim come loose from the wheel when tire deflation occurred on the road.

The method of applying and dismounting the tire from the Baker rim is by the drop-center method not by the split-rim method. Tires in 5.25, 5.77 and 6.00-in. sizes have been used on this wheel for an average of more than 10,000 miles with no reported wheel, rim or tire trouble.

Other Tests Inconclusive

Other tests completed or under way indicate inconclusive results when using larger than 4.40-in. balloon-tires on drop-center rims. The general impression among car engineers is that, whatever advantages drop-center rims have, these appear to be confined mainly to light and medium-weight cars. The application and removal of large balloon-tires with stiffer side-walls have been found to be difficult even when tools are used. When deflation occurs on the road, the weight of the larger cars has inflicted severe tube-damage in a number of instances.

Attempts have been made to use the drop-center rim on light commercial-cars. While excellent tire-mileages have been reported, considerable difficulty has been encountered with rim breaks. The drop-center rims tested did not seem to be as strong as the present flat-base rims.

More Development Work Needed

Decidedly more rim and more wheel development-work therefore, seems to be in order in America if progress is to be made in adapting the drop-center rim to medium and heavy-weight automobiles, as well as to light, medium and heavy-weight commercial-vehicles. Necessary tire changes can be worked-out quickly, but cannot precede wheel and rim development.

Motorcycles Need Straight-Side Rims and Tires

Development work is badly needed and, to a small extent, it is under way to fit drop-center rims to American motorcycles. The present clincher balloon motorcycle-tire is very difficult to apply, particularly on the smaller-diameter motorcycle-wheels. Balloon motorcycle-tires are of two-ply construction; therefore, they are very flexible and are run at comparatively low inflation-pressures. Clincher beads must fit tightly to hold firmly to the rim on sharp turns at high speeds. Such conditions appear to demand an inextensible-bead straight-side tire. Therefore, the field seems wide open for the development of some form of straight-side rim and wire-bead tire for all types of American motorcycle.

Future Outlook

Immediate or even early approval in America of a detachable-wheel drop-center tire and rim combination for all sizes of automobile is difficult to forecast. If early approval is obtained, considerable confusion is likely to result from the use of improperly fitting casings and tubes. The degree of success of the steel-spoke wheel with 4.40-in. drop-center tire will have an important bearing on the problem. American automobilists are used to the demountable flat-base rim and, to that extent at least, are rather firmly attached to it. They are also well schooled in strong-arm, hammer and tool methods of applying and removing tires from demountable rims, which methods are menaces in the path of the drop-center-rim program. Perhaps demountable drop-center rims can be developed successfully to embody light weight and low costs. Weight may be waived for a time in America, but costs cannot go unrecognized for long.

Another important factor is the export trade. In the future, the world outside of America must take a considerable proportion of American-built cars. Export tastes must be considered and cultivated carefully. It is not likely that export demands will alter American preference for flat-base rims and present tires immediately; however, the field outside is becoming important so increasingly that it may exert an influence on our tire, wheel and rim design which cannot long be withstood.

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Indicating the High-Speed Multi-Cylinder Internal-Combustion Engine

By H. M. JACKLIN[1]

SEMI-ANNUAL MEETING PAPER *Illustrated with* DIAGRAMS

ABSTRACT

AN indicator claimed to be the only known device for certain and economical obtainment of composite indicator-diagrams depicting power, offset and lower-loop effects on high-speed multi-cylinder internal-combustion engines is described, the broad field of usefulness for such an instrument in furthering the development of high-speed engines by enabling accurate investigation of the processes within the engine cylinders having long been apparent, since the ordinary indicator fails at engine speeds above 300 r.p.m. due to inertia effects on its pencil mechanism and its drum. Because of the great need for obtaining accurate indicator-cards at high engine-speed, it was determined to construct a device that would produce diagrams having little or no inertia effect included, from the cylinders of an engine operating at any speed, and to make these diagrams available for analysis immediately, without recourse to photographic or other processes.

Briefly, a standard slow-speed indicator having a drum 1½ in. in diameter is coupled directly by a standard union to the part of the device that has inside it a small poppet-valve which is opened for a very small interval of each cycle of the engine and which, when opened, completes communication between the manifold of the engine and the indicator. The indicator cylinder is filled with heavy lubricating-oil to provide a proper seal for the indicator piston and minimize gas transfer to or from the engine cylinder during each engine cycle.

Drum motion is controlled by a string threaded over a pulley and connected to a crosshead of the device which can be considered a replica of the engine piston but which moves through one stroke only for each 800 strokes of the engine piston and imparts a very slow back-and-forth movement to the indicator drum, thus nullifying inertia effects. The crosshead is controlled by a connecting-rod adjustable as to length and a graduated crank-disc, forming a train having exactly similar characteristics to those of the train that controls the engine piston. Since the connecting-rod can be varied in length, the ratio of the rod and its crank-disc can be made precisely the same as the ratio between the corresponding parts of the engine. The crosshead guide can be adjusted to simulate the offset of cylinders, if such offset exists, and the device can be made available for use on all types of internal-combustion engine and for connecting-rod to crank-throw ratios varying between 3¼ to 1 and 5½ to 1.

A shaft on the device passing vertically upward from another shaft driven at engine-speed turns at one-half engine-speed. The horizontal shaft carrying a hand crank is driven, when the clutch is engaged, at 1/40 engine-crankshaft speed. This horizontal shaft drives the vertical shaft to which the graduated crank-disc is attached through worm-gearing having a reduction of 20 to 1; so, with clutch engaged, this disc is driven by the engine at 1/800 of engine-speed and actuates the connecting-rod of the device. With the clutch disengaged, the graduated crank-disc can be operated by the hand crank in either direction.

Details and illustrations of the construction, application, procedure, and operation are included. This indicator has been in successful operation for more than 500 hr. of testing and research work at Ohio State University. The composite indicator-diagram obtained over a great number of engine cycles which, individually, are generally not alike, is claimed to be a distinct gain over anything else yet tried, since the diagram is built-up before the eyes of the testing engineer.

NEED for obtaining indicator diagrams from the cylinders of engines operating at more than 300 r.p.m. has been existent since the internal-combustion engine first came into use, because of the difficulties due to inertia effects when using the conventional, thoroughly logical and simple indicator such as that used ordinarily on air compressors and steam and gas engines operating at the higher speeds. Pencil-motion inertia is usually the most apparent, although that existing in the drum is often present. Attempts have been made to use some means of deflecting a beam of light and thus obtain a photographic record but, although this method has shown many things and has been invaluable in many investigations, its greatest objections are the danger of distortion of the record in development or printing and the great length of time ordinarily required, in addition to the cost, to make the record available for analysis in test or research work. So, the first two parts of the problem are to (*a*) provide a device for obtaining diagrams having few or no inertia effects from the cylinder of an engine operating at any speed and (*b*) produce a device that will draw diagrams which are available for analysis immediately without recourse to photographic or other processes. Further, if we wish to use such a device on a multi-cylinder engine, the problem is more complicated.

It is desirable also to arrange to obtain an average record over a considerable period, so as to secure results that are useful and comparable, since a spot-diagram, that is, a diagram of one single cycle, may or may not be representative of average conditions. Generally, such a diagram is not representative even on a slow-speed internal-combustion engine using a gas as fuel, as is well known to anyone having experience. With liquid fuels, the problem is complicated further by the introduction of other variables.

If it is possible also to arrange the apparatus so that we can obtain not only the conventional power-diagram but also offset diagrams that will show the combustion-line in greater detail, and lower-loop diagrams by which we will be able to study the effects of changes in the induction or the exhaust systems, we then will have a device by which we can make a complete analysis of the cylinder action. Finally, if the device can be arranged to take all the foregoing dia-

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grams from each of the cylinders of a multi-cylinder engine on but one indicator of the conventional type, the investment in testing apparatus is reduced and all diagrams that are obtained are made easily comparable to all other diagrams of the same type.

Work on this rather complicated problem was begun about 2½ years ago by C. P. Roberts and myself, and the result of this work is presented in the JR indicating-device herein described. It seems logical to present first a discussion of some diagrams obtained by using this device before describing the device itself.

Power and Offset Diagrams

Fig. 1 shows five pairs of typical diagrams taken on a 2½ x 5-in. single-cylinder air-cooled Delco-Light engine having a volumetric compression-ratio of about 3.63 to 1.00. The upper diagram of each pair is easily recognizable as being the power diagram. The lower diagram is called an "offset" diagram because the crank operating the indicator drum is offset 90 deg. from the position used when making the power diagram. Ignition occurred at 20 deg. before dead-center position in all five runs. The offset diagrams were made so that the compression stroke is shown at the right end with ignition occurring at the line marked 20, which means 20 deg. before dead-center. The vertical line marked 0 is then the dead-center position for the engine.

Thus, in run, No. 347, combustion began at 20 deg. before dead-center and the pressure in the cylinder became greatest at about 30 deg. past dead-center. It is apparent that, knowing the engine-speed, it is easily possible to arrive at a time-rate of pressure increase within the cylinder at dead-center, constant volume, by measuring the slope of the combustion-line at its intersection with 0-deg. line.

The purpose of the tests from which these diagrams are selected was to show the effects of multiple ignition. Therefore, the cylinder-head of this very small engine was fitted with four spark-plugs identified as Nos. 1, 2, 3, and 4. Spark-plug No. 1 was the plug as ordinarily fitted in this engine's cylinder-head; No. 2 was placed at 90 deg. from No. 1 and under the inlet-pipe; No. 3 was located opposite to No. 1; and No. 4 was set below the exhaust-valve. The four plugs were thus spaced 90 deg. apart and all were pointing horizontally into the cylinder. The diagrams in Fig. 1 were selected so that the air-to-fuel ratios for each were closely alike. Upon examination it is seen that, with spark-plugs Nos. 1 and 3 placed opposite, the cylinder gives about as good results as can be expected without too great expense for ignition apparatus. The differences in operating conditions are readily apparent from the power diagrams, and the offset diagrams show very clearly the details of the combustion-line for each combination of spark-plugs.

I have been asked whether the device will produce time-pressure diagrams. It should be apparent now that, if such diagrams are necessary, they can be constructed rather easily from the power and the offset diagrams; however, with these two diagrams available, the observer will hardly need a true time-pressure diagram. The question as to how the vertical lines are located on the offset diagram may arise. A dummy from which these lines can be traced easily is made by drawing a circle of a diameter equal to the diagram or card length and laying off the piston travel for each 10 deg. of crankpin travel, using a connecting-rod length exactly proportional to the length of the connecting-rod used in the engine.

Fig. 2 shows diagrams similar to those in Fig. 1, except that they show the effects of changing the air-to-fuel ratio when spark-plug No. 1 is firing in all cases. The diagrams for the 12.22 to 1.00 and the 13.21 to 1.00 air-to-fuel ratios show the greatest mean-effective-pressure which is to be expected. The slow-burning rich-mixture and the slow irregular-burning lean-mixtures are readily apparent from these diagrams.

Lower-Loop Diagrams

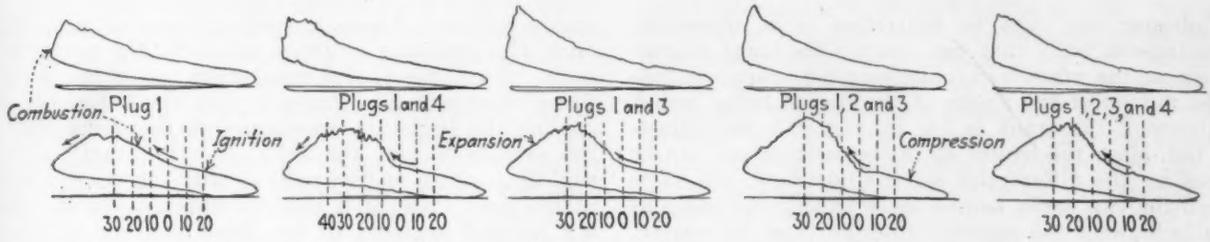
The lower-loop diagrams shown in Fig. 3 are very interesting in that they show how sensitive the device is in operation. Owing to the necessity for measuring the air going to the engine and the location of the main exhaust-header in the laboratory, both the inlet and the exhaust pipes were between 8 and 10 ft. in length. The effects of the pipes being long are apparent in diagram No. 1 in Fig. 3, wherein the exhaust-line shows pressures below atmospheric for the greater part of the stroke and in which the pressure within the cylinder at the beginning of the compression stroke is above atmospheric. For diagram No. 2, the clearance of the inlet-valve was changed. The increased suction necessary in the early part of the inlet stroke is very apparent in this and in the succeeding diagrams. For diagrams Nos. 3 and 4, changes were made in the clearance of the exhaust-valve alone. These changes are apparent in the raising of the exhaust-line. In the multi-cylinder engine all lower-loop diagrams from each of the cylinders should be exactly the same in shape and of the same area below the intersection of the exhaust and the compression-lines to make certain that each cylinder is getting its fair share of the mixture.

While I have not had occasion to try the following procedure, it seems that, by using a 40 or a 50-lb. spring with a stop for its protection as in the case of the diagrams of Fig. 3, it easily would be possible to make studies as to the valve action by utilizing the conventional lower-loop diagram and also an offset lower-loop diagram. Possibly, small changes in valve-seat angle, cam contour and the like can be studied to the betterment of our knowledge of these matters. It certainly is logical that lower-loop diagrams will afford considerable information as to the effects of changes in diameter, length and the contour of both inlet and exhaust-manifolds.

It should be apparent from the diagrams that they are not spot-diagrams. Each small irregularity in these diagrams shows that consecutive cycles were not exactly the same, since but a small part of each diagram is taken from any one individual cycle of events. The diagrams are built-up, part-by-part, on the card, the whole forming a composite diagram of the conditions within the cylinder. The larger irregularities, such as after-burning waves, are repeated again and again on successive diagrams, there being cases in which as many as six diagrams were as near alike as the proverbial two peas. These composite diagrams have been construed as average diagrams by almost everyone who has seen them made. While I feel sure that the diagrams do represent average conditions, I prefer to call them "composite" diagrams since they are built-up from many cycles of the engine.

The JR Indicating-Device

Three views of the JR indicating-device are shown in Fig. 4, which is an assembly drawing. The device should be mounted on the engine being tested so that the manifold is opposite or above the center of the cylinder-head. This manifold is connected to each of the several cylinders by air-cooled or water-cooled tubes,



Run No.	347	346	345	344	343
Card Area, sq. in.	1.035	1.026	1.052	1.067	1.097
Card Length, in.	2.840	2.850	2.840	2.846	2.850
Mean-Effective Pressure, lb. per sq. in.	58.300	57.700	60.300	60.100	61.500
Air-Fuel Ratio	15.150	14.960	15.560	15.450	15.450
Engine-Speed, r.p.m.	1,060	1,060	1,060	1,060	1,060
Spring Scale, lb. per in.	160	160	160	160	160

FIG. 1—TYPICAL JR INDICATOR-DIAGRAMS

Five Pairs of Diagrams Taken on a 2½ x 5-In. Single Cylinder Air-Cooled Engine Having a Volumetric Compression-Ratio of about 3.63 to 1.00 Are Shown, the Upper Diagram of Each Pair Being the Power Diagram. The Lower Diagram of Each Pair Is Called an "Offset" Diagram Because the Crank That Operates the Indicator Drum Is Offset 90 Deg. from the Position Used When Making the Power Diagram. Ignition Occurred at 20 Deg. before Dead-Center in All Five Runs. The Purpose of the Tests from Which These Diagrams Were Selected Was To Show the Effects of Multiple Ignition

all tubes being of the same length to obtain exactly comparable results. These tubes generally will be connected into the holes used ordinarily for priming cups.

The ⅝-in. shaft projecting both ways from the base should be driven from the accessory or other convenient shaft at engine-crankshaft speed.

A slow-speed indicator, such as the Crosby, the Trill or some other make, having a drum 1½ in. in diameter is then mounted directly on the part *a*, which is machined to take the particular union furnished by the indicator manufacturer. This indicator should always have its pencil motion pointed downward, since its cylinder must be well filled with 600-W or other fairly heavy lubricating oil. This oil serves a two-fold purpose; first, it produces a very good seal around the indicator piston, thus reducing the rate of leakage very materially and, second, it reduces the clearance in the indicator cylinder to such an extent that the volume of gas transferred to or from the engine cylinder then being tested is confined to an infinitesimal volume from the individual cycle.

DRUM MOTION IS SLOW

The motion of the drum of the slow-speed indicator is controlled by a string threaded over the small pulley shown above the part *a* and connected to the small grooved-pin on the crosshead. This crosshead can be taken as a replica of the engine piston, but it is moved at a very slow speed in comparison with that of the engine piston; therefore, the drum of the slow-speed indicator is moved back and forth very slowly and, in fact, the engine piston makes 800 strokes to 1 stroke

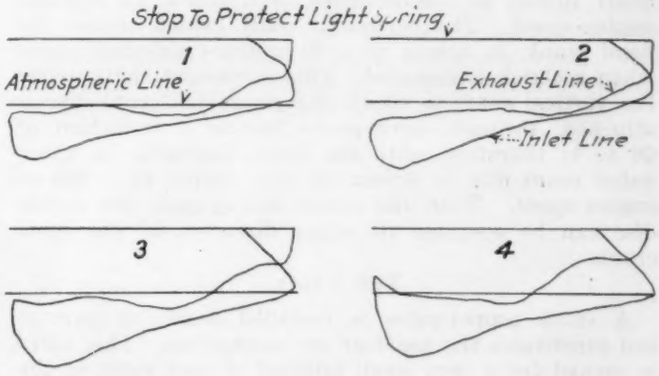


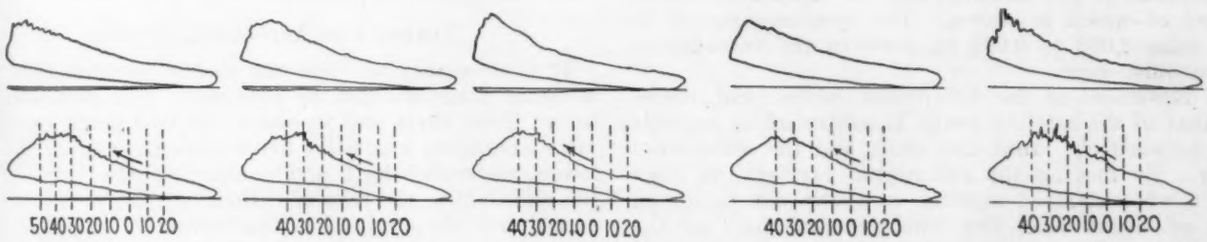
Diagram No.	1	2	3	4
Inlet-Valve Clearance, in.	0.008	0.037	0.037	0.037
Exhaust-Valve Clearance, in.	0.010	0.010	0.021	0.037
Engine-Speed, r.p.m.	1,170	1,180	1,190	1,120
Spring Scale, lb. per in.	8	8	8	8

FIG. 3—LOWER-LOOP DIAGRAMS ILLUSTRATING THE GREAT SENSITIVENESS OF THE DEVICE

Diagram No. 1 Shows the Effects of the Long Pipes for the Inlet and for the Exhaust; for Diagram No. 2, the Clearance of the Inlet-Valve Was Changed; for Diagrams Nos. 3 and 4, Changes Were Made in the Clearance of the Exhaust-Valve Alone. These Changes Are Apparent in the Raising of the Exhaust-Line

of the crosshead. This slow motion nullifies all the inertia troubles that enter if it is attempted to move the indicator drum in unison with the movement of the engine piston.

The crosshead is controlled by a connecting-rod-and-crank mechanism. The connecting-rod is made adjustable as to length, so that the motion of the drum of



Run No.	358	357	348	347	425
Card Area, sq. in.	1.050	1.070	1.073	1.035	0.990
Card Length, in.	2.870	2.850	2.850	2.840	2.880
Mean-Effective Pressure, lb. per sq. in.	58.400	60.000	60.200	38.300	33.000
Air-Fuel Ratio	10.860	12.220	13.210	13.150	18.150
Engine-Speed, r.p.m.	1,060	1,060	1,060	1,060	1,060
Spring Scale, lb. per in.	160	160	160	160	160

FIG. 2—OTHER TYPICAL DIAGRAMS

These Are Similar to Those in Fig. 1, Except That They Show the Effects of Changing the Air-to-Fuel Ratio When Spark-Plug No. 1 Is Firing in All Cases. The Diagrams for the 12.22 to 1.00 and the 13.21 to 1.00 Air-to-Fuel Ratio Show the Greatest Mean-Effective Pressure, Which Is To Be Expected

the indicator can then be controlled by a crank-and-connecting-rod train that has exactly the same characteristics as the crank-and-connecting-rod train controlling the motion of the piston of the engine being tested. The throw of the crank is 1⅝ in. and it is not adjustable; but, since the length of the connecting-rod can be changed by the differential screw-adjustment, the ratio between the two easily can be made exactly the same as the ratio between the corresponding parts of the engine. Further, as shown in Fig. 4, the crosshead guide can be adjusted to stimulate the offset of the cylinders of the engine, should the engine have offset cylinders. The device is thus made available for use on all types of engine, whether they have offset cylinders or not, and for connecting-rod to crank-throw ratios varying between 3¼ to 1 and 5½ to 1.

Relative Speed of Crank-Disc and Engine

The shaft passing vertically upward from the ⅝-in. shaft driven at engine-speed is operated at one-half engine-speed. The horizontal shaft, which carries the hand crank, is driven at 1/40 engine-crankshaft speed when a clutch is engaged. This horizontal shaft drives the vertical shaft to which the graduated crank-disc is attached, through worm-gears having a reduction of 20 to 1; therefore, with the clutch engaged, the graduated crank-disc is driven by the engine at 1/800 of engine-speed. With the clutch disengaged, the crank-disc can be operated in either direction by the hand crank.

The Valve

A small poppet-valve is installed inside of part *a*, and constitutes the heart of the mechanism. This valve is opened for a very small interval of each cycle of the engine being tested. The valve head is located to the left of the part *a* so that, when opened, it completes communication between the manifold and the indicator attached to part *a*. The valve is made carefully so that no packing is required on its stem to prevent leakage from the indicator cylinder from cycle to cycle of the engine.

Variable Valve-Opening During the Cycle

The vertical shaft on the center-line X-X is in two parts, the upper part being driven from the lower part through a conventional differential-mechanism. Attached to the upper shaft is the small disc *c*, the purpose of which will be explained later. Disc *d* has a hollow extension that encloses the upper shaft and carries a cam within the housing at point *e*. This cam operates the small poppet-valve through a suitable rocker-lever, also enclosed in the housing, and an adjustable tappet, the end of which is shown. The clearance should be made from 0.003 to 0.005 in. between the valve-tappet and the valve-stem.

The movement of the differential carrier and, therefore, that of the satellite gears, is controlled by suitable gears between the crank-disc shaft and the differential carrier. By moving the differential carrier, the discs *c* and *d* when clamped together as shown can be moved faster or slower than the lower vertical-shaft as the case may be. This means that the cam can be advanced or retarded with reference to some particular point in the engine cycle. The gears between the crank-disc shaft and the differential carrier are proportioned so that the cam is advanced or retarded one full turn for two turns of the crank-disc. Since the crank-disc shaft rotates very slowly, the cam is only moved very slightly from cycle to cycle. Thus, the pressure within the engine cylinder forces a small volume of gas into or from the indicator cylinder at a certain point in the cycle. While the engine crankshaft makes the next two turns, the crank-disc moves a very small distance, thus moving the indicator drum through the connecting-rod, the crosshead and the cord, and the cam is moved slightly forward or backward so that the valve is opened in the next cycle at a slightly different point. Hence, but a small segment of the final diagram is obtained from an individual cycle of the engine.

Crank-Disc Use on Multi-Cylinder Engines

The crank-disc is made regularly with 24 drilled and reamed holes spaced equally on the circumference of a circle of 1⅝-in. radius as shown in Fig. 4. The stroke of the crosshead is then 3¼ in. A movable crank-arm is mounted on this crank-disc. This crank-arm is held in position by the point of the knurled screw that fits into any selected hole in the crank-disc. This crank-disc can be considered as the crankshaft of the engine, operating at a very low speed. The hole marked 0-360 deg. can be considered as the crank for cylinders Nos. 1 and 4 of a four-cylinder engine. In this case, the hole marked 180 deg. would be the hole used in obtaining power diagrams from cylinders Nos. 2 and 3. In the case of a six-cylinder engine, hole 0-360 deg. might be used for cylinders Nos. 1 and 6. Hole 120 deg. would then be used either for cylinders Nos. 2 and 5 or Nos. 3 and 4, and hole 240 deg. would be used for cylinders Nos. 3 and 4 or Nos. 2 and 5 according to the firing order of the engine. In the case of an eight-cylinder engine with equal firing intervals, the 0, 90, 180, and 270-deg. holes would be used. This standard crank-disc can be used on any engine for which the firing intervals are in multiples of 15 deg. Hence, it can be used on a 30, 45, 60, or 90-deg. V-type engine. If it should become necessary to test a 42-deg. V-type engine, it is possible to replace this crank-disc with another having its holes specially located.

In the case of the four-cylinder engine already mentioned, the offset diagrams are made by using the hole at 270 deg. for cylinders Nos. 1 and 4 and the hole at 90 deg. for cylinders Nos. 2 and 3. In like manner, a hole at 90 deg. from the hole used to obtain a power diagram can be used in all cases for obtaining offset diagrams.

In obtaining lower-loop diagrams, the same holes in the crank-disc are needed as when obtaining the power diagrams. It is necessary to provide a rather light spring for use in the indicator, and also a stop on the piston of the indicator to protect the indicator spring from distortion and damage.

Timing the Indicating-Device

It is necessary to time the device so that true and accurate diagrams can be obtained. The procedure is to set three parts and to clamp but two parts together, after arranging a positive drive from the engine for the lower horizontal-shaft and connecting the tubes from the manifold to the several cylinders. Let it now be assumed that the engine has four cylinders and that it is desired to use holes 0 and 180 deg. in obtaining the power and the lower-loop diagrams. First, the engine must be set so that pistons Nos. 1 and 4 are on their upper dead-center. Second, turn the movable crank so that the knurled pin can be placed in hole 0 deg. of the crank-disc. Then turn the crank-disc until the crosshead is in its upper dead-center position, where it can be held by a timing-pin, not shown in Fig. 4, dropped

through another of the holes into a hole in boss *f*. Third, it is necessary to arrange to have the valve open at this time. This is done by loosening the cap-screws holding parts *c* and *d* together, so that part *d* can be rotated to have the hole *g* opposite a corresponding hole in boss *h* on the housing. Another timing-pin is then put through boss *h* into hole *g* to hold part *d* in position while the cap-screws that make a unit of parts *c* and *d* are being tightened. The engine is now on dead-center for pistons Nos. 1 and 4, the crosshead is in its corresponding dead-center position, the cam is in position to hold the valve open and the timing clutch *c d* is tightened. The timing-pins in the crank-disc, and in the cam-disc *d*, should now be removed.

Operation on the Engine

All selection valves should be closed and the cooling-water should be circulating around the tubes and through the manifold before starting the engine. A suitable spring is placed in the indicator and its cylinder is filled with heavy oil before attaching the indicator at part *a* and connecting the cord from the drum to the crosshead. With the engine warmed-up, it is now necessary to open the selection valve to cylinder No. 1, to have the crank-pin in hole 0 deg., and to engage the clutch whereby the entire mechanism is operated by the engine. This clutch, which is a jaw-type clutch, is engaged by pulling the hand crank axially as indicated in Fig. 4. The diagram for cylinder No. 1 will then be built-up part-by-part, 1600 revolutions of the engine crankshaft being required to complete it. The mechanism can then be stopped by moving the hand crank axially to disengage the clutch. A new card can then be placed on the indicator drum, the selection valve to cylinder No. 1 closed and that to No. 4 cylinder opened. A diagram can then be obtained from cylinder No. 4. To obtain diagrams from cylinders Nos. 2 and 3, it is not only necessary to open the proper selection-valve but also to change the crankpin to hole 180 deg. in the crank-disc. A similar procedure is necessary on six and on eight-cylinder engines, care being taken to select the proper holes in the crank-disc and to open the proper selection-valves.

The Cam Throw-Out and the Atmospheric Line

At times, it is advisable to operate the engine without operating the valve in part *a*. Provision is made to do this by lifting the pin *j* and moving the lever *k* into the position shown in dotted lines in the top view. This moves the cam follower away from the cam by means of an eccentric inside the housing.

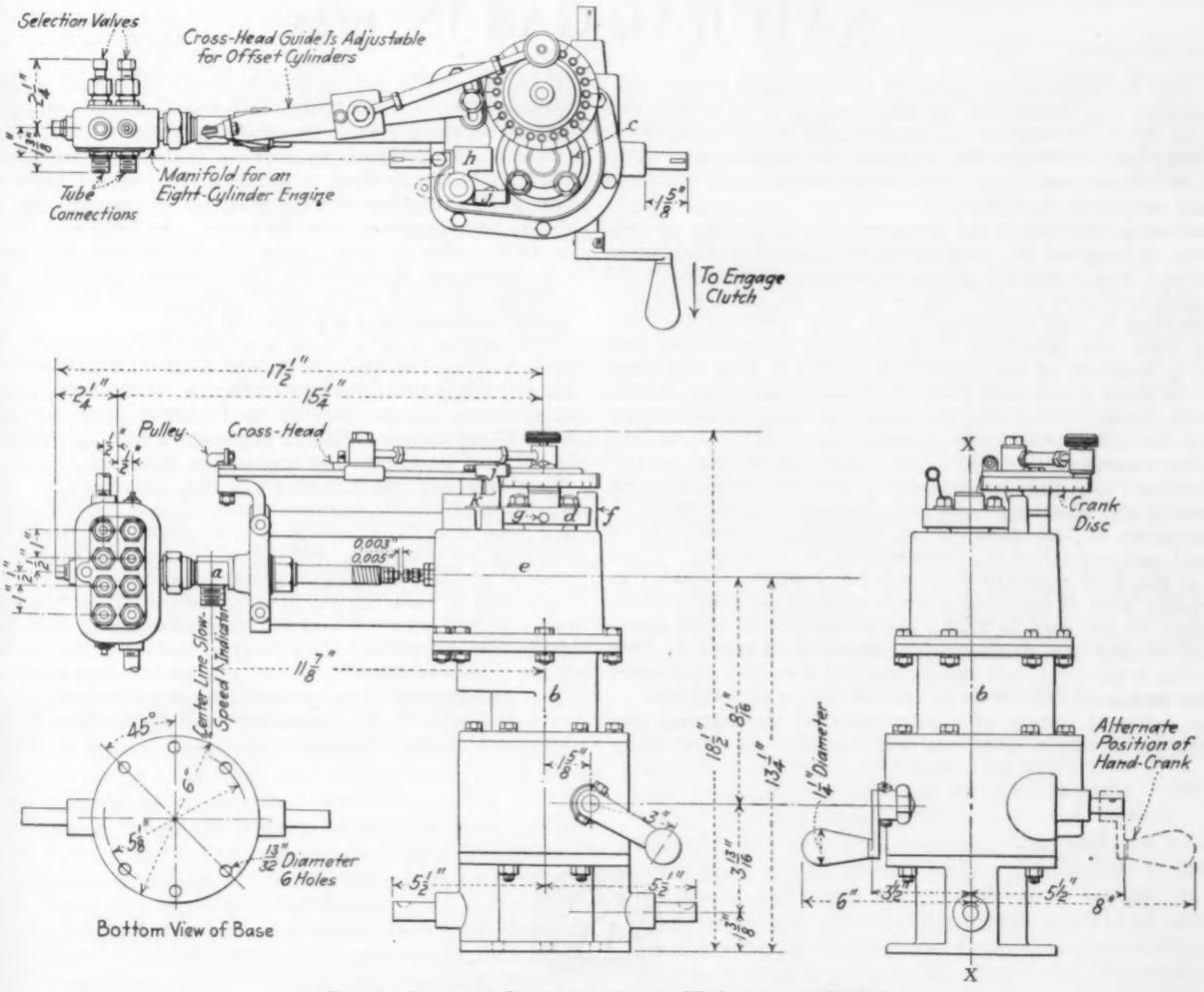


Fig. 4—Assembly Drawings of the JR Indicating-Device

The Device Should Be Mounted on the Engine So That the Manifold Is Opposite or Above the Center of the Cylinder-Head. This Manifold Is Connected to Each of the Several Cylinders by Air-Cooled or Water-Cooled Tubes. The Shaft in the Base Should Be Driven from the Accessory or Other Convenient Shaft at Engine-Crankshaft Speed. The Slow-Speed Indicator Can Be Placed at Any Angle Desired, So Long As the Oil Seal Is Maintained, by Turning Part *a* to the Proper Position. The Manifold Also Can Be Turned to Any Desired Position; in Fact, the Tube Connections and the Selection Valves Can Be Reversed if Necessary

The atmospheric line can be obtained when testing a four or a six-cylinder engine by opening one of the extra selection-valves and pulling the cord by hand while the valve in part *a* is operating. On an eight-cylinder engine, a small relief-cock can be fitted into one of the small plugged-holes in the manifold and operated for this same purpose.

Advantages in Test Work

The advantages of this type of indicating-device are many, even now, although the field for it has not been investigated extensively. The composite diagram, built-up over a great number of cycles which, individually, are not generally alike, is a distinct gain over anything else that has been tried before. The diagram is built-up part-by-part before the eyes of the test engineer; so, he always has a check on operating conditions from the viewpoint of the engine portion of the testing equipment. The diagram is then available for study and analysis as soon as drawn, without recourse to photographic or other processes.

By means of the crank-discs any part of the cycle, such as the combustion-line, can be extended over a large part of the diagram, thus enabling a more minute study to be made. Offset diagrams easily can be made to show the valve action in greater detail than is indicated in the lower-loop diagrams shown in Fig. 3. The device enables rapid and accurate work to be done when investigating the fluid processes of multi-cylinder engines which, to date, can be accomplished only by expending a great amount of time and money. In fact, such investigations have not yet been made, although the need certainly exists. Variations in valve timing, valve lift, ignition timing, and other things affecting individual cylinders become apparent immediately and can be corrected.

The Field for the Device

To date, one of these indicating-devices has been used for at least 500 hr. of test and research work in the engineering experiment station at Ohio State University, and has given entire satisfaction as to performance and results. The device easily can be used in routine or line test-work in manufacturing. If small and inexpensive provisions are made on engines in production, the device can be used in service-stations to check valve fits, ring fits, ignition setting, carbureter adjustments, and other things that, at best, are now done only by guesswork.

NATURAL GAS IN 1924

IN 1924 the natural-gas industry in the United States made another high record by the consumption of 1,141,482,000,000 cu. ft., which had an estimated value of $105,779,000 at the wells and of $253,830,000 at points of consumption. This total is 13 per cent more than the consumption in 1923 and almost double that of 1914.

Increased production, as measured by deliveries to consumers, is recorded for most of the States and in California, Louisiana and Texas the gains range between 58,000,000,000 and 33,000,000,000 cu. ft., but on the other hand a smaller output than in 1923 is reported from West Virginia, Pennsylvania, Ohio and Montana. West Virginia passed from first place in quantity of gas produced, a rank it had held since 1909, to third place, and Pennsylvania receded from fourth to sixth place. These changes mark the passing supremacy of the Eastern States in the production of natural gas and a closer approach in rank of the States producing natural gas to those that produce petroleum, and they emphasize the increasing use of casing-head gas obtained from oil wells.

The ratio of the domestic to the total consumption of natural gas continued to decrease and in 1924 only 25 per cent of the total quantity was used for domestic purposes as contrasted with 28 per cent in 1923, with 33 per cent in 1922, and with 38 per cent in 1921. Nevertheless, the total quantity of natural gas utilized by domestic consumers in 1924 increased 3 per cent, and the number of domestic consumers in 1924 increased 209,600 to the record figure of 3,443,400.

The value at points of consumption of the natural gas utilized for domestic purposes was considerably more than the value of the natural gas that was consumed industrially, although the volume of the latter was three times as much as that of the former. The average value of the natural gas consumed for domestic purposes in 1924 ranged from 29.6 cents per 1000 cu. ft. in West Virginia to 91.2 cents in Missouri, and for the United States it increased to the record high of 54.0 cents, as contrasted with 51.4 cents in 1923 and 38.2 cents in 1920. The average value of the natural gas consumed for industrial purposes in 1924 ranged from 2.6 cents in Colorado to 53.2 cents in Maryland, and for the United States averaged 11.6 per 1000 cu. ft.

The quantity of natural gas reported as treated for recovery of natural-gas gasoline in 1924 was 1,016,276,000,000 cu. ft. This is equivalent to 89 per cent of the total consumption of natural gas in the United States and contrasts with 87 per cent in 1923, 71 per cent in 1922 and 62 per cent in 1920. The growth not only shows increasing conservation of natural gas but indicates the near approach of the time when the available annual supply of gas, which until 1923 had been greatly in excess of the quantity treated for the recovery of gasoline, will be a controlling factor in the growth of the natural-gas gasoline industry.

In 1924 a total of 156,514,000,000 cu. ft. of natural gas was reported as consumed in the production of carbon black in the United States. This total is equivalent to 14 per cent of the total consumption of natural gas, and is almost three times the quantity consumed in the manufacture of carbon black in 1922.—G. B. Richardson and H. Backus in Mineral Resources of the United States.

Inspection, a Means for Economical Motor-Truck-Fleet Maintenance

By F. E. Hatosy[1]

Metropolitan Section Paper

ABSTRACT

PROPER intervals between complete inspections of a motor vehicle are determined mainly from considerations regarding the make and the type of vehicle; the type of driver; the mileage covered and the topography of the route; the recurrences of breakdowns due to failure of the engine, the carbureter, oil-strainers, gasoline and water pipe-lines, valve-tappets, brakes, fan-belt, and the like to function properly; and the length of time elapsing before the body and the chassis bolts become loose.

Enlarging upon the effects of the foregoing items on satisfactory vehicle-performance from both maintenance and safety viewpoints, the author enumerates the main details of adequate inspection, presenting also subsequent discourse on motor-vehicle design that has as its objective accessibility of all the parts for purposes of inspection, repair and replacement, together with mention of the influence such design has on the cost of maintenance.

MOTOR-VEHICLE inspection, when performed properly, is far more effective toward attaining efficient and economical fleet-maintenance than is any other form of shop effort or supervision, the term "inspection" meaning a detailed survey of the vehicle and the preparation of a job card that specifies what work is to be performed. The determination of the proper interval between inspections, how much work should be included in an inspection and what benefit is to be derived are some of the many problems that naturally arise in connection with inspection, but the important factors that largely determine the proper period between inspections are the type and the make of vehicle; the type of driver; the mileage covered and the topography of the route; the recurrences of breakdowns due to failure of the magneto, the carbureter, oil-strainers, gasoline and water pipe-lines, valve-tappets, brakes, fan-belt, and the like to function properly, and the length of time elapsing before the body and the chassis bolts become loose. The intervals between inspections should not be based upon any one or two of the items mentioned but must be determined by a thorough survey of all existing conditions. Some vehicles may perform for 60 days between inspections and others for 20 days, yet they may both maintain the same percentage of safety against road delays and too costly maintenance.

In itself mileage does not mean very much. Ten miles of heavy hauling over busy city streets may be as costly to an operator as double that distance outside the city limits where fewer emergency stops and less acceleration are necessary. Further, mileage in a mountainous or undeveloped region cannot be compared with mileage run on level suburban thoroughfares.

It is a regrettable but well-known fact that there are two distinct types of driver, the "careful" and the "careless." Sometimes it seems that the careless driver is in the majority. We hear no complaints due to the careful driver and he always keeps his vehicle going; but the careless driver continually has trouble of some kind, either imaginary or real, his vehicle breaks-down often and, though it may be serviced three times as often as that of the careful driver, it is the source of numerous complaints. The type of vehicle has an important bearing on determining inspection periods. It is hardly necessary to point out the difference in the ability of good standardized equipment to perform, as compared with the performance of a mongrel fleet or one composed of "half-orphan" vehicles.

A proper system of inspection aids greatly the ability of the shop to produce more thorough work; the flow of work is better controlled and inspection helps to eliminate the erratic peaks and emergency jobs that cause much of the work to be slighted and improperly done. It also tends to reduce the so-called "temporary" and "good-enough-for-a-couple-of-days" jobs to the minimum.

Complete overhauling of a motor vehicle is seldom necessary if proper inspection is practised because the vehicle receives the needed attention at the right time throughout its life, and it is improbable that all units will wear-out at the same time. Inspection is also important after the vehicle has been repaired in the shop. This inspection must be thorough as well as the one given the vehicle prior to its entering the shop, because the final result depends upon it. The quality of work produced by the average shop-mechanic may be no better than the quality of work required at this final inspection unless the poor work is reported, as the tendency of men not endowed with responsibility is to perform their work with the least physical and mental effort. If a job improperly or carelessly done is passed at the final inspection, the man who did the work feels that it must have been satisfactory, and he will continue to do that class of work with a clear conscience. The final inspection should reveal the true conditions and, if unsatisfactory, the mechanic who worked on the job should be told of its poor quality. After a workman has learned that nothing but a thorough job will pass inspection, and that all unsatisfactory jobs will come back to him, he is likely to form the habit of doing good work.

Details of Inspection

An inspection consists of checking approximately 200 parts of a vehicle. The man who carries on this important work necessarily must have a complete understanding of motor-vehicle construction and design, "horse-sense," good eyesight, keen hearing, and the ability to make good use of needed tools. The ability of the various units and their component parts to last until the next inspection, allowing the proper margin of safety for breakdowns, is determined from this inspection of the vehicle before it enters the shop. To illustrate, a few items are mentioned which are disposed of on account of the inspection, showing what bearing inspection has on maintenance cost and how it controls the flow of work to the shop and its amount.

[1] A.S.A.E.—Superintendent of maintenance, Motor Haulage Co., Inc., Brooklyn, N. Y.

A "knock" in the engine may result from a loose wristpin or piston, a worn timing-gear, play in the camshaft, worn connecting-rod bearings, or other sources. An inspection determines the cause of the knock, whether the vehicle can "carry-on" efficiently until the next inspection date or whether it should be repaired immediately. Inspection throughout is the taking of a "stitch in time to save nine." For example, if a fan-belt is lost on the road through failure to note its worn condition, it may be the indirect cause of a leaking water-pump or even of scored cylinders, depending, of course, on the type of driver and other conditions. At best, it will, as a rule, mean a road job and delay to the truck. One bad valve in an engine may increase the fuel-consumption 30 per cent, and it seems that a driver is always inclined to abuse a vehicle that is already in poor condition.

In making an inspection, the aim is to derive the maximum wear from all parts that constitute the vehicle and to prevent breakdowns and delay. The operator who removes and discards parts prematurely or when they are not more than 60-per cent worn is one-third less efficient than the one who obtains 80 per cent of their usefulness and still leaves a safe margin of 20 per cent. The operator who attempts to wear-out the vehicle's parts and units completely is following a foolish course, for he will experience numerous road-jobs and mechanical failures due to the small margin of safety allowed. My experience has shown that a 15-per cent margin is a good one to allow.

Much depends on the inspection if all the foregoing procedure is to be carried out. It is regrettable that capable inspectors are very difficult to find, but the services of well-qualified inspectors are, as a rule, appreciated by their employers. An inspector necessarily must be trained for the work. I have found that the training of men by the organization is the most satisfactory method of building-up the inspection force. A man trained in the organization is the most efficient.

Design for Accessibility

Accessibility has an important bearing on inspection and the time consumed in performing difficult operations. In making valve and various other adjustments throughout the entire truck, we have experienced great difficulty in gaining access to the parts. If a vehicle has its water-pump located properly, the magneto may be inaccessible. On many motor trucks, the water-pump is located at the front end of the engine and it is necessary, as a rule, to remove the radiator and the timing-gear case before taking the pump out. Most carbureters are designed so that a special wrench is needed for taking the strainer out.

I have yet to see a proper placing of cylinder-base nuts; it seems to me that engines are always pumping oil and, if the bolts are not tightened-up every month or so, one will have a very dirty engine, lose considerable oil and have a job that is hard to work on. Most gasoline-tanks are under the seat. After about 2 years, it is necessary to remove the cab before cleaning-out the sediment or repairing defects caused by corrosion in the tank. If the tank on several types of vehicle now on the market were an inch shorter or narrower, the tank could be removed through the seat frame without taking off the cab. In filling gasoline tanks, it is often necessary to remove the seat, take off the board that is under the seat, remove the cap, and fill. It would save time and expense if the filler cap were placed on the outside of the cab or truck in a more accessible position, so that the tank can be filled from the outside.

Batteries, when not mounted on the running-board, are usually located under the seat. A door or a removable panel should be provided on the side of the seat frame so that the batteries can be removed from the side. Our vehicles are greased every week, and this is done at night. Each time, the floor-boards must be removed and it is necessary to take out the bolts that hold the floor-boards. The process takes about 5 min. and, in a year, something like $700 is spent in taking-up floor-boards and putting them back again, besides the likelihood of losing bolts. As to lubrication, I would like to see the day when the truck builders install the one-shot system as some of the passenger-car builders are now doing. This would obviate much trouble.

The cooling system of the engine needs improvement. The water cooling-system has caused much trouble and inconvenience in many ways. If the fan-belt slips off, or breaks, if there is any leakage or if the water freezes, trouble is the result. If the engineers who design and the men who construct motor vehicles can obviate such trouble by improving the cooling system, the maintenance of motor vehicles will be simplified to a large extent.

The Discussion

A. F. Masury[2]:—From each $100 worth of truck we sold during 1912, we received $17 from the customer for repairs during the year following its sale. Continuing this analysis down through 1924, we obtained data for a curve which varied to some extent but showed that we received in 1924 $4 for repairs from each $100 worth of truck sold, or 4 per cent. That reduction in the percentage of repairs to investment represents 12 years' work in improving the trucks so that we have reduced the cost of repairs to the customer. In 1912 we were doing $400,000 worth of business on repairs and replacements, and in 1924 we did $6,000,000 worth. In other words, by reducing the cost of repairs to the customer to one-quarter, we increased our business because the repair cost was less and the customers bought more motor trucks. I state these figures as a basis for saying that, aside from obsolescence, truck design has improved. I think it is fair to say that there is a definite period, for each builder's type of truck, after which the truck should be repaired; that is a definite factor with each make. The higher-priced truck will run the longer and the lowest-priced truck will have to be repaired sooner, but these facts can be balanced. In general, the better machine can be kept in repair more easily and will be on the road more.

Many builders fool themselves about when a truck is "off the books." The truck is just as good as it ever was and when it is "off" the books perhaps it should be "on" the books. Obsolescence is more or less an arbitrary matter. We all think that a second-hand truck is almost junk, and I think it cannot be arbitrarily established as to when a vehicle should be "off" the books. It must be carried along at the actual cost figures which should indicate when it should be written-off, rather than scrapped at a predetermined time.

R. E. Plimpton[3]:—In regard to Mr. Hatosy's remarks, I have been studying this inspection problem for several years and find that, as a rule, inspection is little more than guesswork. The mechanic looks at a part and tries to decide whether it should be thrown away; then he goes to the inspector and, if the inspector is in doubt, the

[2] M.S.A.E.—Vice-president and chief engineer, International Motor Co., New York City.

[3] M.S.A.E.—Associate editor, *Bus Transportation*, New York City.

mechanic may go to the foreman or to the superintendent. If repair is to be on a scientific basis, we must get beyond the guesswork stage. Some means must be found of establishing standards that can be followed without depending so frequently entirely on the human element.

If a man inspects 200 parts, as mentioned by Mr. Hatosy, how can he determine when the 60-per cent stage is reached, or the 75 or the 100-per cent stages?

F. E. HATOSY:—That depends entirely upon the experience of the inspector. The only success I have had in getting first-class inspectors was by training them myself. It is not guesswork. The inspector becomes well acquainted with the design and construction of the vehicles; he knows how long the units of a given vehicle have lasted, what their useful life was in the case of similar vehicles. It is just as necessary to use tools when making an inspection as it is to use keen eyes and have good hearing. If an inspector wants to ascertain just how much wear there may be in a spring-shackle, he does more than look at it; he uses a pry-bar and finds out just how heavy the bushing is and everything else pertaining to the part and so on throughout the truck. He is an experienced man and only an experienced man can carry out the work and do it right. To show how good the inspections are, we have no greater difficulty in keeping trucks on the road when they are 7 or 8 years old than we do when they are 1 year old, in regard to road delays, breakdowns or anything else.

W. E. KEMP[4]:—Mr. Hatosy stated, and I know it to be a fact, that he has averaged, for a period of years, 98 per cent of his vehicles on the road all the time. From that, the conclusion can be reached that his inspection system is a real success.

C. O. BECH[5]:—Cost accounting is difficult because of the great volume of accurate records necessary on the tonnage actually handled by various operators. It would be necessary to keep a record of the initial tonnage at the starting point, the mileage to the first delivery, the quantity delivered there, the quantity delivered for the second point, the distance traveled, and the like, to the end of the trip. That seems practically impossible for the average operating-company. But I believe it possible for all to keep a record of the initial tonnage given the truck when it starts and the mileage traveled for the trip. If totaled at the end of the month, tons carried per mile traveled or miles traveled per ton carried can then be calculated, which permits a comparison of performance between different types and sizes of vehicle. For instance, the cost per mile becomes less with increased miles traveled, and the cost per ton is reduced with larger tonnage handled. But the figures between, of tons carried per mile traveled, will give that explanation and permit making adjustments or allowances for the difference. We can set another figure between the tons carried per mile traveled and the cost per mile, which would be the average capacity of the unit under consideration. The larger the capacity is, the higher the cost per mile will be; the smaller the capacity is, the lower the cost per mile becomes. The same valuation applies also regarding the cost per ton delivered. The larger the unit is, provided it is operated to capacity, the lower the cost per ton per delivery becomes and the higher is the cost per mile. I believe that those are the only standardized methods of keeping records for the average operator, and that the items I mentioned first are the main ones to consider in keeping a cost record. If the operator has a large fleet and can divide it into sections, he can compare the performance curve of one fleet with that of another and he can compare also the performance curve of one type, make and size of truck with that of a similar type and size of another make. That, I believe, is the only way that a comparison can be made on cost of operation.

In connection with inspection and maintenance, the "send-off" that a new truck or a repaired truck gets when it is put into service is very important. When a truck or a car has been repaired and is sent out from the shop, if the inspector who is responsible for checking-up the unit to see that everything is in proper order is permitted to go out with that truck or car and demonstrate to the man who is to drive it that the unit is in perfect condition, the driver feels much more responsibility and goes on his way *feeling* that he has a perfect unit. He has no chance to "pass the buck," and he will care for the vehicle better. If the driver is careful and knows that he can depend on the unit, that feeling creates confidence not only in the truck but in the shop. He will feel that he is compelled to take good care of the vehicle because he knows that good work was done on it.

H. G. MCCOMB[6]:—Several years ago I interviewed numerous truck-operators and it seemed to me that they were thinking about many things the builder did not have in mind. Many were thinking unkind thoughts of the builders and I felt in full sympathy with these operators. One man who was using a truck of a well-known make said that before he could put on a fan-belt he had to have the forward end of the truck lying around the shop and, naturally, he felt that the builder was at fault. In the case of another make of truck it was apparent that neither the engineer nor anyone else had ever taken the trouble to confer with a certain large operator. This oprator said he failed to see why the engineer of this company did not learn how to design a water-pump; a centrifugal water-pump did not seem complicated to him, and yet he had been forced to install no less than three of these water-pumps on one truck since he had been operating it. As a result of such experiences it seems to me that too broad a gap intervenes between the designing engineer and his staff and the fleet operators. If I were manager of a factory and not an engineer, I think I would be a cruel manager because I would be strongly tempted to compel the designing engineer to do some repair jobs himself. Then we would see more bolts put into easily accessible places, carbureters placed where they can be reached, and other improvements made. We would never find it necessary to start with the headlamps and take the front part of the truck to pieces at considerable expense before we could put on a fan-belt which is, in itself, a job probably costing 75 cents, if the chief engineer and his staff had more practical experience in repair work; but that is a condition which is not appreciated today, if one can believe the operators.

E. B. NEIL[7]:—If the inspection systems are not carefully developed, the police authorities will constitute themselves inspectors. Several arrests have been made recently in New York City because of "loose front wheels" as the police call faulty steering-gears. In the Police Department at present, the officials are instructing policemen so that they can determine whether a vehicle is faulty in its operation. Probably all are familiar with the brake tests. These were started about 1914 by the New York City Police Department, which is still working along that line to some extent; but the

[4] A.S.A.E.—Eastern distributer, Byrne, Kingston & Co., Kokomo, Ind.

[5] M.S.A.E.—Superintendent of motor equipment transportation, Texas Co., New York City.

[6] M.S.A.E.—New York City.

[7] M.S.A.E.—Consulting engineer, New York City.

steering-gear question is a more recent study. In one particular case the steering-wheel did not have a very large amount of play; it was only about 1 ft. of travel of the rim, although that seems like a large amount. If a great number of taxicabs and passenger cars are examined, it will be found that 1 ft. of travel is none too much if measured by the standards existing on the streets today. I wish to bring out the idea that defects obvious to the police or to anyone on the streets must be prevented by more careful inspection methods maintained by the vehicle operators. Public sentiment continues to be unfavorable to motor trucks and to motor-truck drivers, and this creates a resistance to motor-truck operation.

A bill soon to be brought before Congress, which is indirectly sponsored by the American Railway Association, provides for the regulation of motor trucks engaged in interstate commerce and seemingly aims to place motor trucks in that service under the control of the Interstate Commerce Commission and indirectly under the control of the railroads. This again emphasizes the fact that motor trucks operated on the streets must be maintained very carefully in the interests of public safety, which calls for thorough inspection of trucks carried out in the shops so that the good will of the public will be fostered.

F. B. HANFORD[8]:—In general, research work by the Society is hampered by lack of a laboratory, but fleet operation can be utilized as a laboratory substitute if fleet operators would realize how important all the information they gather is to the Society. A careful analysis of all fleet-operation troubles sent to the Society's Research Department would go a long way toward providing the needed information.

As to the methods used in some shops, one company near New York City that operates about 1200 vehicles sent out a car after a complete overhaul and inspection that, when tested for horsepower, was found to be below the rating at the rear wheels. The engine was performing properly and the trouble seemed to be in the rear end, although the foreman inspected it again and said it was all right. Readjustment of the pinion in the rear end enabled the engine to deliver 25 per cent more horsepower to the rear wheels; but the shop had sent the car out on the road lacking 7 hp. at the rear wheels due to the defective rear-end adjustment.

MR. PLIMPTON:—The accident hazard is a serious one in motorcoach operation. For example, an operator whose motorcoaches had covered many miles without a single injury to a passenger met with an accident. The steering-gear of a vehicle that had seen hard service broke, and the motorcoach went over a bank and a number of passengers were injured. That was a bad thing for the operator and spoiled his fine record. It led me to talk to metallurgists to see whether they can determine a mileage at which those vital parts should be discarded, say at 50,000 or 75,000 miles or whatever the distance might be. I thought that by imitating the operating conditions on a fatigue-testing machine or by using a similar method, performance might be predicted. Thus far, the information received indicates that my scheme is impracticable.

POUL HANNOVER[9]:—In defense of the truck builder against the charge of inaccessibility of truck parts, when an engineer has to build a powerhouse, if he finds he cannot install the needed equipment in a two-story building he can add a third story. In a truck the powerplant must be installed in a very limited space, since every inch that can be saved here is gained for the load, and it is not easy to find accessible space for all the necessary equipment. It is desirable, of course, that engineers should follow-up the service work. In large factories this is done through the experimental department, which calls to the engineers' attention the changes that need be made. Smaller truck-factories generally have their own service-shop and, if anything is wrong with the truck, it is not long before the engineers know about it, as it should be left to them to approve repairs covered by guarantees and consequently not charged to the customer.

Mr. Plimpton suggested that it is desirable that all parts of the ideal truck give the same length of life, but I disagree. Almost all trucks are overloaded, and the only way in which the engineer can limit this is by incorporating some weaker parts on the truck, and by locating these in places where ruptures occasioned by limited overloads will show-up without causing serious damage or accident.

G. A. ROUND[10]:—The various speakers have different opinions in regard to inspection methods, but all the methods seem successful; at least, each company seems satisfied with its own system, although the reasons that all the systems work equally well are not clear to me. There must be some sound fundamental principle that can be applied in the majority of cases to the advantage of all, but I feel that it has not been stated at this meeting. We have begun to pool our information, and that is a step in the right direction, since we must coordinate the work of the operating men with that of the Society. The sooner the operating men pool their information and present it to the Society in concrete terms so that it constitutes data, with which the Society can work, the sooner we will surmount these difficulties in design and operation about which most of the operating men are complaining. If the engineers here could talk with engineers from abroad, it would be realized how prone the foreign engineers are to solve their own problems each in his own way. The designs of European motor vehicles prove that. Contrasting that condition with the situation here, an engineer from abroad who spoke to me last summer regarding the work of the Society as a whole said that it is remarkable to him how the members come to the meetings of the Society and tell each other what they are actually doing; he remarked also what great use is made of the S.A.E. Standards. I think that the Motor Truck Association's Operating-Men's Club should adopt a similar practice and try to formulate standard methods and cost systems. Much has been done at this meeting to pool our information and put it before the truck builders as sanctioned by all of us rather than by a few individuals only. Every effort should be made to carry on this work, for it will be of benefit to all.

[8] M.S.A.E.—Engineer for J. Anglada, consulting engineer, New York City.

[9] International Cement Corporation, New York City.

[10] M.S.A.E.—Assistant chief of the engineering division, automotive department, Vacuum Oil Co., New York City.

Fuel from the Service Standpoint

By T. A. Boyd[1]

Service Meeting Paper *Illustrated with* Photographs

ABSTRACT

As the automobile, a chemical factory on wheels, converts gasoline and air into energy for propelling itself and its load, its prinicpal problems of operation center on the properties and impurities of the raw materials, the utilization and disposition of the by-products and the proper maintenance of the plant equipment.

After discussing the nature of gasoline, the author enumerates the five sources from which motor fuel is derived. The major part of the gasoline is said to be obtained directly by distillation from petroleum; about one-quarter of American gasoline, to be secured by the cracking of heavier petroleum oils; about one-tenth, to be gasoline that is separated from natural gas; from 1 to 2 per cent, to consist of benzol and similar material; and fuel used in some sugar-producing localities, to comprise alcohol made from molasses.

Among the service problems arising from the use of gasoline are mentioned the presence, in some cracked distillates that have not been properly refined, of a brown varnish-like resin, the formation of which increases with the age of the liquid and the warmth of the place of storage.

Another source of trouble is due to the fact that resinous material tends to collect dirt. If later a blended fuel containing benzol or alcohol is added, the resinous deposit is loosened or dissolved, releasing the dirt, which then collects and clogs screens and small openings.

A gasoline engine manufactures considerable quantities of water. In cold weather, condensed water in the cylinders may form ice and freeze the pistons. Sulphur oxides produced by the combustion of the fuel dissolve readily in water, forming sulphuric acid, which has a corrosive effect on the polished surface of the cylinders and the bearing surfaces in the crankcase. The three remedies proposed are (*a*) prevention of condensation or the collection of liquid water in the engine, (*b*) removing the water after it has been formed and (*c*) using a fuel low in sulphur.

Although most of the fuels in common use are blends of the materials obtained from the first three sources mentioned above and are generally satisfactory, means of accurately determining their characteristics are not usually available and the service man must use his best judgment in selecting them. If gasoline could be made to conform to a universal standard, so far as the volatility characteristics are concerned, the design, operation and servicing of automobiles would be greatly benefited. Surveys having shown that most automobiles use more fuel than is necessary, the suggestion is made that the running qualities of many cars could be improved if the carbureters were adjusted for leaner mixtures, and a plea is made for the conservation of the available fuel-supply.

Attention is called to the hazards arising from the inflammability of the fuel and from the poisonous character of exhaust gases, and suggestions are given with a view to their prevention.

[1] General Motors Corporation Research Laboratories, Detroit.

THE automobile is a chemical factory on wheels. Its principal product is energy—energy for moving itself and the load it bears along the road. Its by-products are the waste gases scavenged from its cylinders and the unburned carbon deposited in its engine. The raw materials upon which this rolling chemical-factory operates are gasoline and air.

And so, although the service man may not think of his work in this way at all, an important part of the service he renders to transportation is the maintenance of a chemical plant, with all the specialized problems incident to it. Even the electrical energy that illuminates the path of the motor car and that pulses through the wires of its ignition-system is generated in a chemical storage-battery.

In a chemical plant, the principal problems of operation usually center not so much around the production of its primary product as around the properties and the impurities of its raw material, the utilization and disposition of its by-products and the proper maintenance of the plant equipment. Gasoline, the wonderful raw material upon which the powerplant of the automobile operates, has always been taken as a matter of course. There are times, however, when an intimate knowledge of the properties of the materials going into the chemical plant that propels the motor car would be of great assistance to the service man in his effort to maintain the whole machine in its best operating-condition.

Composition of Fuel-Mixtures and Exhaust Products

First of all, let me show you what goes into the automobile engine and what comes out of it. Table 1 ties together in a quantitative manner the principal facts about the composition of the fuel-mixture breathed in by the gasoline engine, and about the products blown out of its exhaust-ports. This shows that 1 gal. of gasoline and 1200 cu. ft. of air give a total volume of exhaust products of 1350 cu. ft. for the ideal engine and 1130

TABLE 1—COMPOSITION OF THE AIR-FUEL MIXTURE AND OF THE EXHAUST FROM AN AUTOMOBILE ENGINE

Constituents of the Air-Fuel Mixture

	Lb.	Cu. Ft.
Carbon	5.26	—
Hydrogen	0.99	190
Air	—	1,200

Constituents of the Exhaust

	Actual Engine		Ideal Engine	
	Lb.	Cu. Ft.	Lb.	Cu. Ft.
Carbon Dioxide	10.0	87.00	19.40	165.00
Water	6.9	0.83[a]	8.95	1.07[a]
Carbon Monoxide	5.9	80.00	—	—
Hydrogen	0.2	40.00	—	—
Oxygen	0.2	2.00	—	—
Unchanged Nitrogen	—	775.00	—	1,000

cu. ft. in an average engine, both figures being approximate. Although this is a comprehensive and interesting table, we have not time to comment upon it, other than to call attention to the manner in which it illustrates the point we have just tried to make, namely, that the automobile is a chemical factory.

As indicated by Table 1, the materials breathed in by an automobile engine are gasoline and air. Gasoline is a chemical compound of carbon and hydrogen, which it contains in the proportions given in the table. The air that the engine must have, or it will suffocate, consists of a mixture of nitrogen and oxygen. Considering the large volume of air required to burn 1 gal. of gasoline, all of which costs the motorist nothing, it is apparent that the "Free Air" sign at gasoline filling-stations has a much greater significance in motoring than merely for the inflation of tires.

It can be seen that the composition of the gas which issues from an automobile engine is entirely different from that which entered it and was digested in the engine's fiery stomach. A thing to which I would particularly call your attention, because of its importance in connection with some things to be said later, is the fact that, for each gallon of gasoline the engine burns completely, it manufactures more than 1 gal. of water. As suggested by Table 1, the automobile is a soda-water factory on wheels. Of course, nearly all the soda-water manufactured in the engine cylinders is blown out through the hot exhaust-pipe as an invisible vapor, so it is not recommended that anyone try to secure his supply of seltzer water from the end of the exhaust line.

In interpreting this table, it should be borne in mind that the engine products listed there are only its by-products. The valuable thing that the engine manufactures is the heat energy with which it moves the motor car from place to place. The table does not attempt to show, either, what disposition the engine makes of such impurities as may be present in the fuel, a thing that is important to the service man and will be touched upon presently.

The Nature of Gasoline

The old Greek philosophers of centuries ago thought that everything in the world was made up of little unit parts or particles. A house was built of thousands of stones. Each stone consisted of many, many little grains; and each grain, in turn, contained an extremely large number of still more-minute units.

The last and tiniest particle of any substance they called an atom, meaning thereby that it was indivisible. As the Greeks conceived things, a mobile material, like a liquid or a gas, was composed of round, smooth atoms that would not hold together. But a solid, like iron, was formed of rough atoms with "hooky" surfaces that clung to one another.

Modern scientists have found out that the Greeks were partly right. Everything, whether solid, liquid, or gaseous, is composed of little grains. And this is true of petroleum, too. Petroleum being a very complex mixture, the particles composing it are not all of uniform size, but they vary in size from small to large. Gasoline is the lighter portion of crude oil and is separated from its miscellaneous sources by a process that amounts simply to screening the smaller or finer particles out of it. Some of the products obtained from a barrel of crude oil are listed in Table 2.

TABLE 2—WHAT COMES OUT OF A BARREL OF CRUDE OIL

Product	Per Cent	Gal.
Gasoline	31.6	13.30
Fuel and Gas Oil	47.6	20.00
Kerosene	8.9	3.75
Lubricating Oil	4.1	1.70
Wax, Coke and Asphalt	3.7	1.55
Miscellaneous	1.2	0.50
Loss	2.9	1.20
Total	100.0	42.00

* Gallons.

So the liquid we call gasoline is a miscellaneous aggregation of tiny particles. And, when gasoline is breathed into the automobile engine as a vapor, its invisible particles of division swarm in the air like dust of the minutest size. But no ordinary dust was ever so fine, so inconceivably minute. Fifty million of these infinitesimal particles would have to be placed side by side to measure 1 in. "How do we know that?" you ask. Well, for one thing, when a little gasoline is dropped on a smooth surface of water it will spread out and out and out into a film only 0.00000002 in. thick. Naturally, the thickness of the film cannot be less than one molecule, for that is the ultimate particle of division. Although such a thing is utterly beyond conception, it may be said, for sake of completeness, that there are a hundred billion times a billion of these tiny molecules in just a single one of the little charges of gasoline that go into a cyclinder of an automobile engine. It is no wonder that so fine a dust burns with enormous power.

Sources of the World's Motor Fuel

Practically the whole motor-fuel supply of the world comes from five sources, as follows:

(1) The major part of it is distilled directly from petroleum. As was intimated above, this amounts, in effect, to screening the finer particles from the complex crude-oil supplied by Nature

(2) About one-fourth of our American gasoline is made from petroleum oils that are too heavy, that is to say, the particles of which are too large for motor fuel, by splitting the large molecules into smaller ones. This is done by the very simple process of heating the heavy oil to a high temperature and under pressure. In effect, it amounts to the same thing as breaking-up a lump of coal that is too large for the furnace into smaller ones of suitable size. In the case of coal, the "cracking" is done with a hammer, but with oil it must be done by heat

(3) About one-tenth of the gasoline produced in the United States is separated out of natural gas, a considerable part of which contains gasoline vapor much as the air contains moisture

(4) From 1 to 2 per cent of the motor fuel used in the United States, and a larger percentage in some of the European countries, consists of benzol and similar material, by-products obtained from coal in the manufacture of coke

(5) In some sugar-producing localities abroad, to which American automobiles are exported, alcohol made from molasses is being used to a considerable extent as motor fuel

Some Service Problems Arising from the Fuel

With these references to the nature and the source of our motor fuel, necessarily very brief, we proceed at once to a discussion of some of the specific automotive service-problems introduced by the fuel.

The fuel service-problems met with most frequently, of course, are those common ones arising from the presence of water, or dirt, or rubber, or some other foreign material, in the fuel system. These it is unnecessary to discuss here. There is much precedent upon which the manner of handling such problems is based, and they are taken care of in the regular service-routine. Ordinarily, gasoline is a fairly uniform material and one that is reasonably well adapted for use in automobile engines. And so, if the systems through which it is supplied are kept clean, the fuel does not present frequent problems to the service man; but sometimes unusual conditions do arise, which then become all the more serious just for the very reason that they are infrequent.

One undesirable and troublesome characteristic sometimes possessed by cracked gasoline and mixed fuels containing cracked distillates is that occasionally a brown varnish-like resin separates from them in carbureters and manifolds and on intake-valves. The deposit is thickest and toughest on surfaces that are warm during operation, and from which the gum-containing gasoline evaporates, leaving its dissolved varnish behind.

In some cases, the deposit of brown tar becomes so bad that it causes moving parts, such, for example, as throttle-valves and intake-valves, to stick, and so actually prevents operation of the engine. One instance came to my attention some time ago in which the throttle-valve of the carbureter of a fire-engine became so badly gummed up that the frantic firemen could not move it enough to get the engine started at all when the fire-alarm rang wildly in their station.

Presumably, this gumming occurs only when the cracked distillate has not been properly refined. Fortunately, it happens on occasions that are comparatively infrequent. The problem has been solved by the refiner, for the most part at least, by suitable treatment of the gasoline in the refining process. But cracking of heavy oils to gasoline is done very extensively in this Country now, and rightly so, because the fuel thus produced is essential to the maintenance of our tremendous volume of automotive transportation. Hence, it is not surprising that, on rare occasions, trouble results from some product of the refinery having gone bad.

The formation of resin in a stored gasoline increases with the age of the liquid, and the warmer the place of storage, the more rapid is the increase. Thus, in the case of the infrequently used fire-engine mentioned above, gasoline probably remained in its fuel-tank for months before it was all used. Not only this, but it also stood there at the warm temperature of the engine-house, hot in summer and steam-heated in winter. Certainly, those were ideal conditions for the formation of resinous compounds in the fuel.

We secured a sample of the gasoline from the fuel-tank of this ill-fated fire-engine. This liquid is now 4 years old. When first collected, it looked like any other gasoline. The fact that it contained a varnish-like gum in solution could not be known, except by carefully evaporating a sample of it in an open vessel. But now, after having stood in a cabinet in our laboratory for so long, the gum in the liquid has increased until it can no longer all be held in solution, and a considerable pool of resin has separated and collected at the bottom of the bottle.

Fig. 1 is a view of the intake-valve of an engine that had been run on a gasoline containing gummy constituents. Note the tar that has baked on its upper face and stem. In this case, inasmuch as the valve is from a

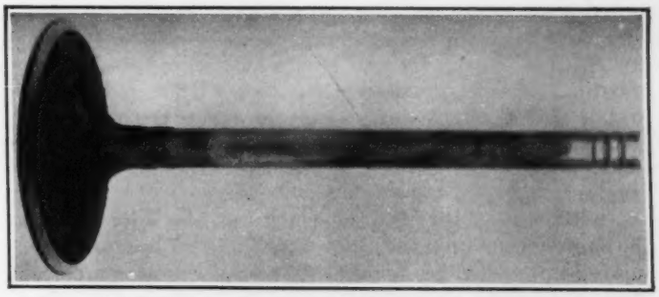


FIG. 1—INTAKE-VALVE FROM ENGINE RUN ON GASOLINE CONTAINING GUM-FORMING CONSTITUENTS

Tarry Coke Is Baked on the Upper Face and Stem. The Sticky Deposit on the Stem Held This Valve Open and Stopped the Engine, Which Happened To Be a Single-Cylinder One

single-cylinder engine, the engine finally refused to run, because the intake-valve was held open by the sticky resin deposited on its stem. The air-passages of a carbureter, in another case, became so heavily coated with a dark-brown resin, or tar, left there by the gasoline that had evaporated from it, that a slow stream of tar ran down and out of the open end of the carbureter.

In the service station, a coating of this gum can easily be removed from surfaces on which it has been deposited by washing them with acetone. Alcohol can be used, but acetone is much more effective. The only means available to the service man for really correcting the trouble, however, in case he should encounter it, is to prevent further deposits of gum by changing the fuel to one that does not leave a resin in the induction passages.

Probably a more common trouble that results from the tendency of gasoline to deposit resins arises in the following manner. A very small quantity of resinous material will separate from almost any gasoline that stands for a long time in the fuel container of a car. Settling there, it binds together such dirt as may come into contact with it. Then, some time if a blended fuel containing benzol or alcohol should happen to be put into the fuel system, this resinous dirt-containing deposit, being somewhat soluble in such liquids, is loosened or dissolved away, setting free at the same time the dirt that it holds. The result is that screens and small openings quickly become clogged with the freed sediment, not because the new fuel itself is undesirable, but simply because it has the property of cleaning out deposits of gum previously made by gasoline. The only remedy for such a condition, of course, is to clean all the dirt from the fuel system in a thorough manner. From the nature of things, the new fuel may usually be relied upon to loosen the dirt, thereby putting it into shape for removal.

CORROSION RESULTING FROM THE FUEL

As the relation of fuel to engine corrosion has been discussed in two other papers[2] presented at this meeting, I shall refer to it only briefly. Your attention has been called above to the fact that a gasoline engine manufactures much water. Sometimes part of this water condenses to a liquid directly in the combustion-chamber, as, for example, during the starting and warming-up of a cold engine. In case an engine should be started from the cold state and then be allowed to fire only a few charges, the inside of its cylinders may remain wet with condensed water. If an engine in that condition be allowed to stand for some time when the temperature is very low, the water in its cylinders may even form ice and freeze the pistons tight. The cooling-systems of automobile engines are made to take care of hot summer temperatures. They are so adequate, therefore, that

[2] See THE JOURNAL, December, 1925, p. 605, and January, 1926, p. 35.

during operation on cold winter days and nights, cylinder-walls may for a considerable time remain cold enough to chill water out of the steam-laden products of combustion. During cold weather, too, a little of the water vapor in the burnt gases that blow past the piston into the cool crankcase of some engines condenses out there as a liquid and becomes a menace to polished bearing-surfaces.

In the crankcase or other parts of the engine, water is bad enough in itself, but sometimes it becomes much more of a hazard by having other products of combustion dissolved in it. Nearly all liquid fuels contain a minute quantity of sulphur, some much more than others. During the combustion of the fuel the sulphur burns, too, producing its oxides, sulphur dioxide and sulphur trioxide. For the most part, these burnt products of sulphur are blown away from the engine with the regular exhaust-gas and are harmless. The oxides of sulphur, however, have the property of dissolving readily in liquid water and, when they do so, of forming acids, one of which is the familiar sulphuric acid used in the storage-battery of the car.

If an engine happens to be afflicted with the bad combination of water in its cylinders, or its crankcase, and of too high a concentration of sulphur in the fuel upon which it operates, a small portion of the burnt sulphur will dissolve in the water, making a weak acid out of it. The effect of such a situation is much the same as if a small quantity of dilute battery-acid had been thrown into the engine. Whether the familiar saying that water and oil will not mix is true or not, the fact remains that any acid water in the lubricating system of an engine will reach the bearing surfaces by being forced or pumped along with the oil.

Illustrating the effect of this condition, Fig. 2 shows a number of wristpins taken from cars run on fuels too high in sulphur. In this view the corroded and roughened bearing surfaces of the parts are plainly visible.

The ways to correct this situation are three (*a*) to prevent the condensation or collection of liquid water in the engine, (*b*) to remove it after it has been formed and (*c*) to use a fuel that is low in sulphur. Anything that assists in heating the jacket-water quickly and in approximating summer operating-conditions by keeping the powerplant warm helps to prevent condensation of water in the engine. Winter-fronts and jacket-water thermostats are examples of such accessories. In the case of engines not provided with an effective means of keeping water out of the lubrication system, it is advisable to change the oil frequently in winter. Although the service man has no direct control over the fuel that is used in the engines he must service, he can help to prevent the distribution of those high in sulphur by bringing to the attention of the customer and of the purveyors of the fuel he burns, the effects of too much sulphur in motor fuel.

Federal Specification on Sulphur in Gasoline

By suitable treatment in refining, the sulphur content of motor fuels can be kept low enough for safety in use. The Federal specification for Government gasoline states that the liquid shall not contain more than 0.1 per cent of sulphur. But some materials sold as motor fuels have been known to contain from seven to eight times this percentage of sulphur.

In what has been said above, it is to be understood, of course, that sulphur in the condition in which it occurs in motor fuels is not acid. It becomes acid in character only after it has been burned in the engine and has come into contact with water in a liquid condition. In the fuel, it occurs in the form of neutral organic compounds, the detection and quantitative determination of which is a highly technical procedure that must be performed by one familiar with that art.

Sulphur is sometimes present in motor fuels, also, in a form directly corrosive to copper and to metals containing copper. In such cases copper strainer-screens are apt to be eaten away or changed into a dark and brittle condition; and other copper or brass parts, such, for example, as those in the carbureter and the vacuum tank, may be corroded or eaten away to a greater or lesser degree. This trouble does not happen often, but when it does occur the only remedy is to change the fuel to one that does not contain sulphur in a form that will corrode copper.

These troubles, resulting from sulphur in the fuel, as well as those due to gummy constituents in gasoline, are practical illustrations of the fact mentioned early in the paper that, in a chemical plant, service problems arise as much from impurities in the raw materials used as from anything else.

Fuel of Improper Characteristics

We do not have very much of the old-time straight-run gasoline these days. The greater part of the motor fuel is made now by mixing liquids from two or more of the five sources already enumerated. For example, much of our American gasoline is made by mixing materials from the first three of the sources mentioned, namely, a liquid distilled directly from petroleum, one made by cracking heavier oils and one extracted from natural gas.

Such a method, when used intelligently as, be it said to the credit of the refiner, nearly always is done, makes a satisfactory motor-fuel. Straight-run gasoline has no advantage peculiar to it alone. So far as behavior in use is concerned, it would not be possible to distinguish between a straight-run gasoline and a mixed fuel made of components in the proper proportions from the first three of the five sources mentioned.

But sometimes persons who distribute gasoline have sold mixtures of liquids not well suited for motor fuel. Such a blend might contain, for example, either a quantity of a too-high-boiling naphtha, or too much of a very volatile material, such as casing-head gasoline. In the first case, the car would be sluggish in operation, because the fuel would not vaporize readily enough. In the second case, the car might be sluggish or erratic in operation, because of gasification of the liquid in the fuel lines and carbureter jets.

Unfortunately, the only reliable means of learning just what the characteristics of a fuel are is to make a laboratory examination of it. The facilities for doing this are not generally available to the service man, of course; consequently, about the only thing he can do is to use his best judgment in the matter.

It would be a very good thing if all gasoline could conform to a universal standard, so far as the volatility characteristics are concerned. This is something that we should have, because it would help much in the design, the operation and the servicing of automobiles. Although the time may not yet be ripe for a universally uniform fuel, the extension of cracking, the process by which a heavy oil difficult to vaporize is broken down into one easy to vaporize, is fast rendering possible the making of motor fuels of uniform volatility everywhere within reasonably close limits. If all motor fuels were of the same volatility, it would help not only the service man but also everyone who drives an automobile.

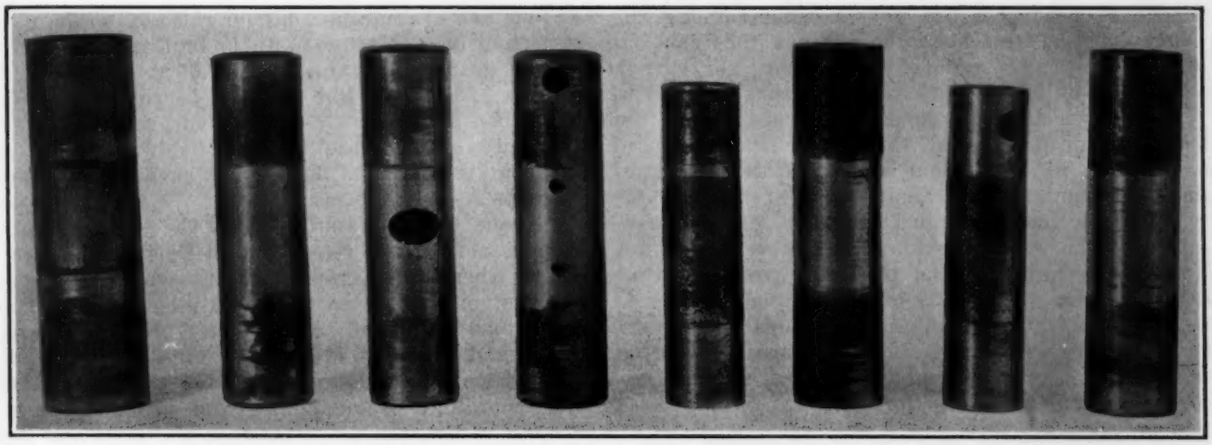


FIG. 2—CORRODED WRISTPINS FROM ENGINES RUN ON FUELS TOO HIGH IN SULPHUR
The Corroded and Roughened Bearing-Surfaces of the Parts Are Plainly Visible

THE SERVICE MAN AND FUEL ECONOMY

One valuable contribution that a service man could make to the welfare of automotive transportation is to do what he can toward increasing the number of miles that automobiles can run on 1 gal. of gasoline. Careful surveys have shown that most automobiles use much more fuel than is necessary, even for the flexible operation that American motorists demand. As a matter of fact, a leaner mixture would improve the running qualities of many cars, for some automobile engines are too greatly overfed to give the best operation. The carbureters of some of these cars, unfortunately, have been adjusted to their inefficient settings in dealers' service-stations, where for the most part the attention given to fuel economy is notoriously insignificant indeed. The low price of motor fuel makes the ordinary automobile-owner indifferent to the gasoline mileage obtained from his car. The consequence is that many automobiles get only about two-thirds the mileage from a gallon of gasoline that should be obtained, and some only one-half what they would get if the adjustments with which the car is provided were properly set. Although such disregard of economy is not at all justifiable, it is not to be expected that automobile owners will show as great concern for the welfare of automotive transportation as should those of us who are devoting our lives to the automobile industry.

IMPORTANCE OF FUEL CONSERVATION

It is needless to say that the future of the automobile business and the benefits that the automobile confers upon society are dependent upon an adequate supply of liquid fuel. We know that plenty of this valuable material is to be had now, and we have reasonable hopes of a supply for years to come. But, at best, the future is not so certain as the present. Should we not do our utmost to conserve what we know we have? "A bird in the hand is worth two in the bush."

Considerable money is being spent in the automotive industry today in research on methods of getting more miles per gallon from motor cars; certainly a very desirable and commendable thing to do. But, at the same time, we know that a large gain in miles per gallon could be secured by adjusting cars carefully before they are placed in the hands of the public, and by giving the users a little education on how to drive the cars properly and efficiently. This is a thing that could be done by service departments better than by any other agency.

I am stressing this point, because I believe it to be one of the most important of those presented in this paper. Our use of Nature's valuable fuel is too much like a herd of swine in a corn field, inelegant simile though it may be. We trample down and waste as much as we utilize sometimes. The low price of motor fuel should not blind us to the necessity for safeguarding the very cornerstone of our industry and all that it means to the world. It is not a question of price at all. It is one of inherent value and of security for the future welfare of the greatest transportation-unit ever developed.

FUEL HAZARDS IN SERVICE STATIONS

Two hazards that the fuel introduces into service stations may be touched upon. One of these, that arising from the inflammable nature of such liquids, need be mentioned only in passing. The fact that gasoline burns readily is just the thing, of course, that makes it a good motor-fuel. It is always the aim of the service man to handle gasoline and other inflammable liquids with full consideration for their dangerous nature. But he handles them frequently, and the natural result often is that "familiarity begets contempt." It is sometimes easier to drain a carbureter on the floor than into an approved vessel. The sewer, also, is a very convenient place into which to throw waste gasoline. And so it goes, until more hazards from fire exist in many service stations than are at all necessary. The problem here is simply one of vigilance.

The second hazard, that arising from the presence of engine exhaust-gases in rooms in which mechanics must work, is one that should receive more serious attention from the service man than it has in the past. It is common knowledge that the exhaust from gasoline engines nearly always contains a quantity of the poisonous gas, carbon monoxide. Table 1 shows that under ordinary operating-conditions about 6 per cent of the exhaust from the engine is carbon monoxide. At the low-load conditions under which engines are run in service stations, however, and sometimes cold, as much as 12 or 13 per cent of the exhaust may consist of this poisonous gas. Unless provision is made for piping engine exhausts to the outside, a thing that builders of service stations have done all too infrequently in the past, every bit of this poisonous gas is blown out into the air that those who work there must breathe.

It is true that the concentration of carbon monoxide in service rooms very rarely becomes so high that anyone is overcome. But such symptoms of physical de-

rangement as headaches are very common among the men; and, even before a headache appears, the functioning of the system is reduced below par, for carbon monoxide acts by slowly suffocating persons exposed to it. It cuts-down the oxygen-carrying capacity of the red blood-cells until, in effect, the system of the exposed person receives an insufficient supply of this essential element; consequently, he cannot work at highest efficiency. Besides, long-continued exposure, even to concentrations of carbon monoxide that are very low, not enough to cause headache and the other symptoms that go with it, reduces the vitality of the exposed person.

This situation makes it highly desirable that every service station in which cars stand for repair should be provided with means for connecting exhaust pipes directly to the outside and also for ventilating the service room in an adequate way.

Still Other Service Problems

Much more might be said about gasoline and its relation to the servicing of automobiles. Even such important points as dilution of the lubricating oil, relation of the fuel to the knock in engines, effect of fuel characteristics upon economy, and problems arising from the extension of the use of alcohol as motor fuel abroad, have not been mentioned at all. Naturally, such a paper as this can touch only the high spots, so we have tried merely to pause for a little on just a few of the important peaks.

THE DISCUSSION

H. R. Cobleigh[2]:—I would be interested to hear more about the use of benzol fuel. Recently I have been trying out what is known as Mitchell gasoline, which has become available in a limited quantity. Its results in my engine were very remarkable. After I had used that gasoline I could hardly believe that the car was the same. I used it until I discovered, after about 1 week, that the carbon needed to be removed again; it had been removed just before I began using this gasoline. The question immediately arose whether the carbon was caused by the benzol gasoline. I am inclined to think it was due to something else, such as loose piston-rings. I would be interested to know whether any difference in the rate of carbon accumulation can be traced directly to the use of benzol fuel. The benzol fuel that can be obtained is limited in quantity. Sufficient benzol is not available to treat all gasoline, at least to give a mixture of the proportions that seem to be most valuable. The gasoline I have mentioned is 48 per cent benzol.

The quantity of benzol obtainable would not go far toward treating the entire gasoline supply but, before we get too enthusiastic about benzol, it seems to me it would be well to find out whether we shall get reactions. For instance, in some cases corrosion has been evident after the use of benzol; but those who seem to know say that the benzol is not the cause, but that the benzol-treated fuels frequently are higher in their sulphur content, having more than the allowable 0.1 per cent that Mr. Boyd referred to.

T. A. Boyd:—It is well known that, when properly refined, benzol makes a good motor-fuel, provided it is also blended with a suitable distillate. One requirement of a good benzol fuel, which Mr. Cobleigh has mentioned, is that the sulphur content must be kept low. Experience has shown that this can be done. Another is that the percentage in which benzol is blended with the petroleum distillate should not be too high for, as is well known, benzol contains a higher ratio of carbon to hydrogen than does gasoline. As is indicated in Table 1, 1 gal. of gasoline contains about 1.00 lb. of hydrogen and 5.25 lb. of carbon. But 1 gal. of benzol contains 6.80 lb. of carbon and only 0.55 lb. of hydrogen. The result is that fuels of the benzol type are likely to deposit carbon as such; that is, real fluffy black carbon like lampblack. Perhaps it is lampblack.

Anyone who is familiar with the servicing of automobiles abroad will recall that in Germany and in other places where fuels from coal tars are used extensively, the custom is to clean the spark-plugs often. I do not know just how often this is done; probably every 1000 miles, and certainly every 2000 miles at most. Spark-plugs are cleaned there by shaking them in a little device containing some benzol and provided with wire bristles, which run down between the skirt and the porcelain of the plug during the shaking process. Plugs are cleaned very effectively in this manner. The thing that makes it necessary to clean spark-plugs thus is the fact that one of the principal fuels used is the light oil obtained in the manufacture of coke. This liquid, part of which is benzol, is very high in carbon and throws off a fluffy deposit which, if not attended to, may bridge the gaps of the spark-plugs and cause ignition troubles.

About the best I can say of benzol is that, when refined properly and blended with a suitable petroleum distillate, it is a good fuel. A naphtha having too high a boiling-point must not be used, because the resulting mixture is then unsatisfactory from a volatility standpoint, and it must not be too high in sulphur. Benzol fuels, if the benzol is used in proper concentration, are entirely free from knocking in the ordinary automobile. This is probably the thing that has made Mr. Cobleigh so enthusiastic; it smoothed out the operation of his car until he thought he was riding behind a steam engine instead of one operating on gasoline.

Mr. Cobleigh:—Another angle to this subject is interesting. You have said that benzol fuels, if they are sufficiently low in sulphur and free from other impurities, are good fuels. Is there any way in which service managers, or the public when purchasing benzol fuels, can be sure that they are getting a reasonably safe fuel? Some service managers feel that it is necessary to caution patrons not to use benzol on account of the danger due to its being high in sulphur. We cannot expect the public to carry test-tubes and make tests when buying fuel. Have you found any way in which we can be reasonably safe, if we buy the fuel?

Mr. Boyd:—As is the case with all other chemical compounds, there is no way in which the ordinary man can test motor fuel, so far as I know. Such testing is a technical procedure that requires a reasonable amount of apparatus and a certain familiarity with the art. Unless the service man can actually collect samples and have the concentration of benzol and the percentage of sulphur determined, about the only thing he can use as a guide is the reliability of the dealer. It is entirely possible, of course, to collect samples of the fuel and to determine how high the sulphur content is, and what the physical characteristics of the fuel are; but it is like trying to test all the gasoline one buys. Unless the gasoline is bought in large quantities, this is not a feasible thing to do.

Mr. Cobleigh:—The thing that seems to aggravate the situation is that fuel, even from the same source of supply, will vary greatly; one tank-car of fuel may show a low content of sulphur and the next one from

[2] M.S.A.E.—Secretary of service, National Automobile Chamber of Commerce, New York City.

the same company may be high. If that condition prevails throughout the Country, will we, as service managers, be safer in warning our customers not to use benzol fuel, or do you think the risk is insufficient to warrant depriving them of the added pleasure they get from driving with it? You spoke about the knocking being less; it is true that in my case the knocking stopped entirely with the use of the benzol fuel, but I experienced other advantages besides that—decidedly better acceleration and about a 20-per cent increase in economy.

MR. BOYD:—Generally speaking, I do not think that the service man is justified in recommending against the use of benzol fuel. Instances have occurred, of course, in which benzol has caused trouble because of being too high in sulphur, but that is also true of gasoline sometimes. Only when corrosion actually results from sulphur in the fuel would the service man be justified in advising a customer not to use any particular benzol-fuel. In this connection, one should not forget, of course, that rusting in engines has resulted just from water produced by the burning gasoline. Benzol ought to be utilized as motor fuel. When properly prepared it is a desirable fuel and augments the supply. As a matter of fact, we may find it necessary to use it some day, if some of the prophets are right in what they say about the depletion of our petroleum reserves.

If Mr. Cobleigh began to use benzol fuel in cool weather, he would, no doubt, notice improved acceleration and a quicker warming-up of the engine because of the fact that the benzol, boiling at a rather low temperature as compared to that of ordinary gasoline, is more volatile and would approach nearer to what we might call aviation gasoline. On account of its greater volatility it would give more flexible operation, which the Society, working in cooperation with others, has found to be true from its tests on various gasolines. I think the conclusion from these tests was that, if the first 25 per cent of a fuel had a low boiling-point, it would give desirable starting and operating characteristics. That property is exactly what benzol would add to the fuel. The boiling-point of pure benzol is only 80 deg. cent. (176 deg. fahr.) and on the whole the benzol light-oils that are sold are more volatile than ordinary motor-gasolines.

J. WILLARD LORD[4]:—Would it be possible to cut-down the mixture with the use of benzol? Is the chemical mixture of benzol and air higher than that of gasoline and air? You said that of gasoline was 15 to 1 and that of benzol was 12 to 1. In the presence of from 25 to 40 per cent of benzol, is it possible to increase the air in the proper ratio?

MR. BOYD:—Yes. It is generally possible to lean the mixture somewhat, because of the fact that benzol is much heavier than gasoline, having a specific gravity of about 0.88, whereas that of gasoline is only about 0.75. So a gallon of benzol contains more combustible material than a gallon of gasoline. But, as benzol is much lower in hydrogen than gasoline, this factor is offset for the most part. However, to lean the mixture somewhat is possible, and this should be done in using benzol whenever possible.

MR. LORD:—Then a man buying benzol would have to cut-down the carbureter?

MR. BOYD:—Yes; provided he can get better operation by doing so, and the chances are very great that he can.

MR. LORD:—Mr. Cobleigh, did you adjust the carbureter?

MR. COBLEIGH:—Yes; I happen to have a carbureter that has a dash adjustment for rich or lean mixtures. Under ordinary conditions, I set the mixture-lever at about mid-position. With Mitchell gasoline, I can turn it completely over to the lean side.

MR. LORD:—Is that as far as it will go?

MR. COBLEIGH:—It will not go farther than the position at which I got the 20 per cent increase in economy. If the carbureter adjustment is not changed when Mitchell gasoline is used, I doubt whether any increase in economy will result.

MR. LORD:—Would the carbon condition be overcome?

MR. COBLEIGH:—It ought to be helped by making the mixture leaner; but, as I did that, I do not think that was the cause.

MR. BOYD:—While we are talking about increased economy from the use of benzol, it should be borne in mind that in present engines this is not a large factor. If we put it on a basis of heat-units, we find that the actual thermal-content of a gallon of benzol is only from 7 to 10 per cent more than that of a gallon of gasoline. Although benzol is heavier than gasoline, it is much lower in hydrogen, which is an element of very high heating-value. A 40-per cent mixture of benzol in gasoline does not then add much to the total heating-value of the fuel. Hence, adjustment of the carbureter, which benzol in the fuel makes possible, is not very great, so far as leaning it down is concerned. The fact is that nearly every carbureter could be adjusted leaner without changing the fuel at all. After a man has begun to use benzol, he may find that the mixture is so rich that he begins to get fluff carbon, which he did not get from gasoline. The only reason he did not get it before was that gasoline is low in carbon. But the chances are that the mixture was too rich. So, while benzol will allow him to lean the mixture somewhat, it is likely that he could have done nearly the same thing with gasoline alone.

MR. COBLEIGH:—I understand that the distillation process differs somewhat.

MR. BOYD:—So far as I know, two types of fuel of reduced tendency to knock were placed on the market during the last year. One of these is made by cracking at a very high temperature in what is called the vapor-phase process. Ordinarily, cracking has been done by heating a heavy oil to a temperature of about 700 deg. fahr. while in the liquid condition. This results in breaking-down the heavy oil into a liquid that is a miscellaneous mixture, somewhat as if one were to break-up stones in a pile. The finer particles are then screened out for gasoline. But some refiners have begun to vaporize the oil before they crack it, and then they have subjected it to a very high temperature in the vapor phase. This is a much more severe process. In the vapor-phase process, it is somewhat as if each molecule were taken off by itself and dealt a crushing blow. The product of this process is different in that it contains a portion of what are called "cyclics" and aromatics, hydrocarbons that do not have so great a tendency to knock as those ordinarily present in gasoline.

The second type of fuel of reduced tendency to knock is derived from another source entirely. The crude oils found in some of the California oil-fields are different from those produced in the Eastern and Mid-Continent fields. Some California crude-oils contain a portion of the so-called cyclic compounds. The molecules of these have their atoms arranged in a ring, as the chemist

[4] M.S.A.E.—General manager of the service department, Harrolds, Motor Car Co., Long Island City, N. Y.

pictures it, whereas the principal hydrocarbons in the majority of gasolines have their atoms arranged in a chain. But these ring compounds have the property of allowing themselves to be squeezed down tighter before ignition without knocking than the chain compounds have.

Taking advantage of that fact, some refiners have made gasoline from California crude-oil and have sold it as anti-knock fuel, because it is made of different ingredients and produces the same effect as if some benzol had been mixed with ordinary distillate.

A MEMBER:—The idea of increased mileage and carbureter adjustment is something that service men have probably encountered before. Sometimes, if followed out, you will find it is due to getting the carbureter adjustment and the mixture too lean. Then valve troubles due to the burning and sticking of the valves seem to begin. Logically, that is caused by the mixture's being slow to burn and producing more heat in the exhaust gases. It may help in diagnosing the condition of valve trouble to attribute it to excessively lean mixtures.

W. S. NATHAN[5]:—I noticed a newspaper article alluding to the fact that the Northwestern Railroad is considering experimenting with Diesel locomotives and commenting on the fact that the exhaust from Diesel locomotives is different from the exhaust from gasoline-driven locomotives. It stated that the exhaust from a Diesel locomotive would allow the Diesel locomotive to be used in the metropolitan area, whereas that from a gasoline-driven locomotive is dangerous to health.

MR. BOYD:—A Diesel engine runs at a much higher temperature than a gasoline engine. Then, too, its size and speed are such that fuel can be metered to it accurately over its whole range of operation. Also, the flexibility demands made of it are not so extreme as those of the automobile engine. These facts would probably enable the Diesel engine to be adjusted to a leaner mixture, and the high temperature would also enable the carbon monoxide to be kept down. One of the principal reasons that an automobile produces so much carbon monoxide is the necessity for getting flexibility over the whole range of operation, and this with an air-flow induction system. If persons were satisfied to drive automobiles here as they do in Europe, we should not have so much carbon monoxide from gasoline engines. An automobile engine could be operated without producing carbon monoxide, if the necessary sacrifices in flexibility of operation were made for it.

QUESTION:—What methods are best for preventing exhaust-gas fumes from affecting or annoying vehicle drivers?

MR. BOYD:—The best thing to do is to get rid of the obnoxious features entirely. Work is being done toward that end in different places now, and we hope that good may come from it. No one can predict though just how far it will be possible to go. So far as I know, strictly physical means are not effective. Different devices have been suggested, such as chimneys at the rear of the car for carrying the fumes up to the top. Although that might have some advantage from the standpoint of the occupants of the car, it is doubtful whether it would be of value to drivers in general. For instance, if a chimney were placed at the rear of a closed car, the air sweeping over the top of the car would rush down at the rear and with the carbon monoxide from the engine would be stirred up there into the faces of oncoming traffic. Though such things are probably of value on bread and cake wagons, which have loads that should not be contaminated, they do not look very hopeful from the standpoint of benefiting the drivers of vehicles in general. The best way of handling this hazard is to eliminate it.

Some adjustments of the carbureter can be made, and cars can be driven in ways that will reduce the noxious gas, but this requires considerable education and can be carried out only to a certain extent. Although it is not possible to eliminate carbon monoxide entirely by this means, it can be materially reduced if some way can be found to stir-up interest in the saving of fuel, or if drivers can be induced to drive more carefully. The automobile service-man could make a real contribution at this point.

C. L. KNOPF[6]:—Last year the Armour Institute of Technology tested a new type of muffler, which, the inventor claims, will consume carbon monoxide. The muffler is built on the venturi principle and arranged so that air is drawn in from the outside, which not only cools the exhaust gases but also furnishes the necessary oxygen to burn up the carbon monoxide formed in the engine cylinders. The inventor told of making a number of analyses of exhaust gases from trucks and passenger cars and finding the percentage of monoxide very high in some cases; however, with the new muffler the carbon monoxide was practically eliminated. If all of this is true, considerable progress, I think, has been made toward the elimination of poisonous exhaust gases from our city streets.

QUESTION:—What effort, if any, is being made toward a Federal law, similar to the Food and Drug Act, that will control the sulphur-content of motor fuels?

MR. BOYD:—I do not think there is any agitation on that subject insofar as making a law is concerned. The Federal specification covers what is called United States Government gasoline. It specifies that the gasoline shall not contain more than 0.1 per cent of sulphur. But this is not in the nature of legislation at all; it is merely a specification. Refiners make an effort to adhere to it as far as possible, however. It is the standard by which fuels are rated, and refiners who are alive to the situation are taking the sulphur out of their fuel now.

[5] Jun. S.A.E.—Designer, Ajax Motors Co., Racine, Wis.
[6] Lubrication engineer, Sinclair Refining Co., Chicago.

The Automotive Worm-Gear

By L. R. Buckendale[1]

Semi-Annual Meeting Paper *Illustrated with* Photographs and Drawings

ABSTRACT

Progress in the development of automotive worm-gearing is interestingly outlined. Previously to 1912, American experience had been limited almost exclusively to the industrial form, generally of the single-thread type. Introduction of the motor truck required a worm for the final-drive but one having entirely different characteristics from that of the industrial gear. Experience in designing these was lacking, however, as was also the special machinery to produce them. In 1913, machinery was imported from England and since that time development has been rapid.

First efforts were devoted to simplifying the design of the axle as a whole, studying the problem of getting lubricant to the bearings, heat-treating the parts, and improving the materials of construction.

Passenger carrying brought new requirements in the way of higher speed, greater acceleration, less reduction in the rear axle to give more miles per hour with a given engine, and quietness; but, because the conditions under which they operate are better, motor-coaches allow the use of the underslung worm, the propeller-shaft brake and a lower chassis, with the accompanying lowering of the center of gravity of the vehicle and, consequently, an increase in stability.

In 1917 and 1918, study of the mathematical analysis of the principles of tooth contact and angular velocity brought new designs in tooth forms, which are discussed. The salient advantages of the worm-drive are said to be (*a*) silence, (*b*) the fact that it retains its silence throughout its life, (*c*) its ability to resist shock loads without damage, and (*d*) its contours, which may be generated with a grinding-wheel after all the other operations have been performed; consequently, a high degree of accuracy in tooth profile, lead angle and tooth spacing may be maintained. Freedom from knock is attributed to the obliquity of approach of the teeth, to the greater areas in contact, and to the low resonant qualities of the materials used.

Until 1912 American experience with worm-gearing had been limited almost entirely to the industrial form. These industrial applications as a rule, required enormous reductions, and the worms almost without exception were of the single-thread type. Efficiency, of course, had not been seriously considered, and most of the applications had utilized the fact that worm-gearing, designed purposely with an extremely low lead-angle, was self-locking or irreversible.

The motor truck first caused designers to look to the worm for a final-drive. Even though the engines used were of the slow-speed heavy-duty type, the slow vehicular-speed and the heavy gross-weights necessitated a considerable reduction in the final-drive. Previously to 1912 this final reduction was obtained in two steps: the first was usually a bevel-gear set in the jackshaft; the second was a chain drive from the ends of the jackshaft to the road wheels. The ability of the worm-gear to accomplish this reduction in one step and its extreme simplicity was favorable to its adoption as a final-drive.

The motor truck, however, required worm-gearing having entirely different characteristics from those of the industrial gear. High efficiency was a very important factor, and the ability to coast or, in other words, to have the wheel drive the worm with high efficiency was also important. Reductions from 8 to 1 to 13 to 1 were required to take care of the natural speed-ranges of the truck engines, the maxima of which were from 1200 to 1500 r.p.m., and the speeds of the vehicles, which were from 10 to 18 m.p.h.

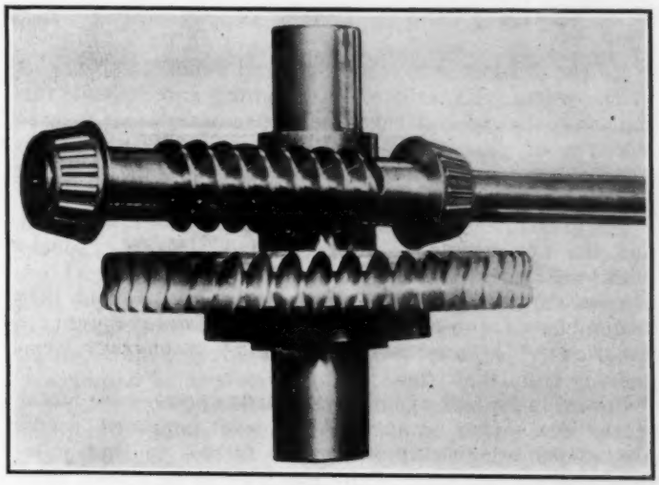


Fig. 1—Typical Industrial Type of Worm-Gearing
The Single-Thread Worm Closely Resembles a Screw Thread

Typical Types of Worm-Gearing

A typical industrial-type of worm-gearing is shown in Fig. 1. Please note the single-thread worm and how closely it resembles a screw thread. A typical truck worm-gear of a 10 to 1 reduction is shown in Fig. 2.

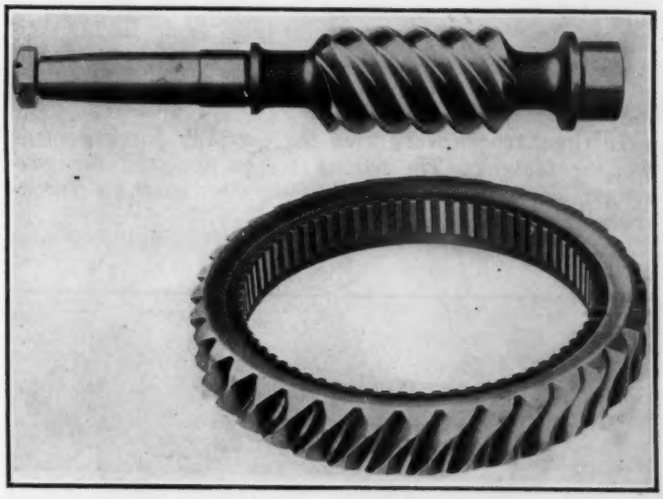


Fig. 2—Typical Truck Worm-Gear Having a 10 to 1 Reduction
Note the Difference in Lead-Angle and General Appearance from That Shown in Fig. 1. Special Machinery for Making This Type of Gear Was Originally Imported from England

[1] M.S.A.E.—Sales and development engineer, Timken-Detroit Axle Co., Detroit.

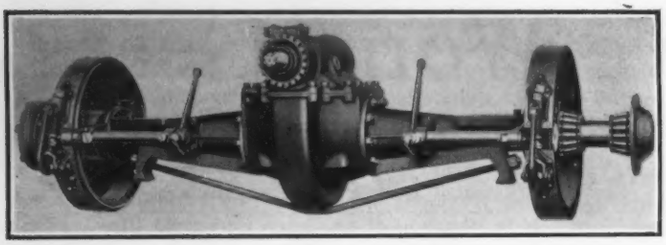


FIG. 3—TYPICAL WORM-DRIVE TRUCK AXLE, COMMON IN 1915

Note the difference in lead-angle and general appearance of the worm. Experience in designing and manufacturing and the special machinery necessary for making the type of gear shown in Fig. 2 were lacking in this Country, and we were compelled to go to England where development in this type of gearing had been made.

David Brown & Sons, Ltd., Huddersfield, England, and the Lanchester Gear Works had already produced worm-gearing of high efficiency and life. American engineers studied their methods and machines, and in 1913 a number of these special machines were brought to America. We have been developing automotive worm-gearing from that time.

Because of a lack of improved roads and because motor trucks are often compelled to leave improved roads. ground-clearance is an important factor, so that practically all applications of the worm-drive to trucks, even those of recent designs, have been made with the worm-shaft overslung.

Most of the effort in axle construction from 1913 to 1917 was concentrated on simplifying the design of the axle as a whole and on studying the problem of getting lubricant to the worm thrust-bearings, which were somewhat inaccessible to lubricant because of their overshot position. It was necessary to develop bearings and a bearing mounting capable of taking the thrust of the worm, which was high because of the large reduction accomplished and the gross weight of the vehicle.

The typical worm-drive truck-axle, common in 1915, is shown in Fig. 3. The worm-drive truck-axle as used today is shown in Fig. 4. Note its clear-cut design and the improved bearing-mounting. Hand in hand with the design work went considerable study in heat-treating. Great progress has also been made in developing materials suitable for use in the worm and worm-wheel. Foundry practice, as applied to bronze and the type of bronze used in the worm-wheel, also came in for considerable development.

SPECIAL REQUIREMENTS FOR PASSENGER CARRYING

In time, trucks were used for carrying passengers as well as freight. The earlier bodies designed for passenger carrying were applied to the existing truck-chassis.

As the business of carrying passengers gathered momentum, study was given to the special requirements for carrying them. It was gradually recognized that these requirements in motorcoaches differed from those in motor trucks. A demand was felt for higher speeds and greater acceleration. This led to engine development with greater maximum-speeds and much greater horsepowers. There was also a demand for less reduction in the rear axle to give more miles per hour with a given engine-speed. Engine-speed maxima rose from 1800 to 2200 r.p.m., and the rear-axle reductions changed progressively from 8 to 1 to 6 to 1. Today, in some cases, these reductions are even 4 to 1. The change in ratios necessitated the development of new methods of production and an intensive study of the principles involved in worm-gearing.

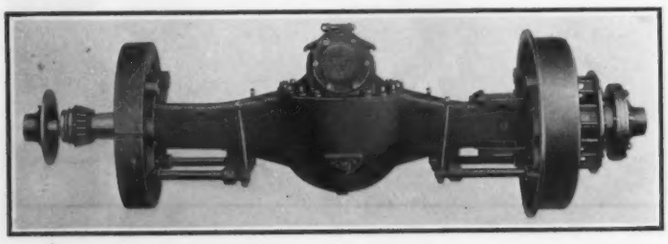


FIG. 4—WORM-DRIVE TRUCK AXLE AS USED TODAY
Note the Clear-Cut Design and the Improved Bearing-Mounting

A typical motorcoach worm-gear with a 4½ to 1 ratio is shown in Fig. 5. The general design of the motorcoach was affected by the greater speed requirements. Coaches became longer and lower. Ground clearance is less important in a motorcoach than in a truck. Because there is not so much necessity for a motorcoach's leaving good road, and because there has been an enormous increase in the mileage of good roads, the practice of underslinging the worm has become common.

ADVANTAGES OF THE UNDERSLUNG WORM

The underslung worm offers many advantages to the chassis designer. It brings the propeller-shaft low and enables the entire chassis up to the floor-line to be lowered. It also removes the necessity for a big ramp or

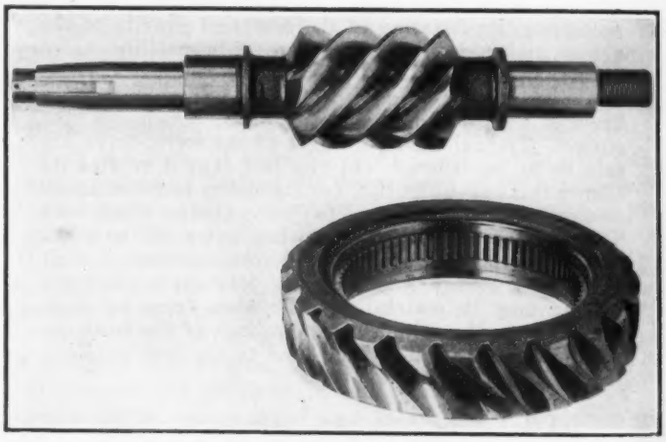


FIG. 5—TYPICAL MOTORCOACH WORM-GEAR HAVING A 4.5 TO 1.0 GEAR-RATIO
The General Design of the Motorcoach Was Affected by the Greater Speed Requirements. Vehicles Became Longer and Lower and Ground Clearance Is Not So Important As with Motor Trucks

projection in the floor-line over the differential housing. This general lowering of the motorcoach, as it departed from truck design, lowered the center of gravity and greatly increased the stability of the motorcoach at high speed and the maximum speed at which the machine could be operated safely.

Formerly it had been thought that worm-gearing could be safely operated only up a certain sliding velocity and that, if this sliding velocity were exceeded, trouble would be encountered. The motorcoach with its high engine-speed and high maximum road-speed quickly taught us that this was fallacious and that no real limit has been reached in the sliding velocity, or the number of revolutions per minute at which a worm-gear set can be operated.

As motorcoach lines were established and vehicles maintained definite schedules, the mileage covered be-

came an important factor. A run of from 350 to 500 miles for a motorcoach per day is very common, and the life of a worm-drive rear-axle in miles was proved to be enormous.

As the motorcoach developed, a greater demand arose for quiet operation. The riding public showed its preference for vehicles that ride comfortably and quietly and compare favorably with the comfort and quietness of passenger automobiles. Passenger automobiles were also going through a period of development. Noise, or rather the lack of it, is a very important factor in marketing either an automobile or a motorcoach.

Worm-gearing is an inherently silent form of final-drive. It is silent at the beginning of its life and, what

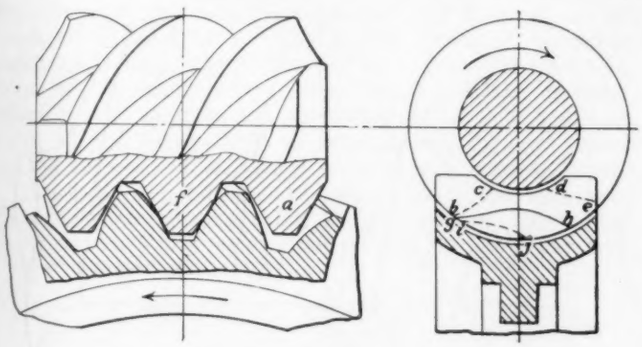


FIG. 6—TYPICAL INVOLUTE WORM-GEAR
In This Gear, the Tooth Form of the Worm in a Plane through Its Axis Is a Rack; the Tooth Form of the Gear in the Same Plane Is an Involute

is still more important, remains silent throughout its entire life. Worm-gearing is not quiet; it is silent.

MATHEMATICS OF WORM-GEARING

In 1917 and 1918, considerable study was devoted to the mathematical principles of worm-gearing. In designing a worm-gear up to that time all the calculations were made in a plane through the axis of the worm and perpendicular to the axis of the wheel. But designers began to question the tooth contacts and general functioning of the surfaces that lay outside this central plane. It had been assumed that, since the tooth form used was an involute, when considered in the medial plane, the angular velocity must be uniform. This would have been true if all the tooth contacts occurred in the central plane; but such was not the case.

In 1920, a paper[2] was read before the Institution of Automobile Engineers by Capt. S. Bramley-Moore, in which a very clear mathematical analysis of the question of tooth contact and angular velocity was discussed, and I will briefly touch on the high-lights as outlined at that time.

The typical involute worm-gear, as we call it, is shown in Fig. 6. In this gear the tooth form of the worm in a plane through its axis is a rack, and the tooth form of the gear in the same plane is an involute. Thread *a* is just beginning to contact with the worm-wheel, and this contact will be approximately along the line *b-c-d-e*. Thread *f*, which is carrying the load, is contacting along the line *g-h*. As thread *a* moves froward in the tooth phase, the line of contact will approach that of *g-h*, while the contact on thread *f* will move down toward *i-j*, at which point the thread *f* ceases to carry the load, and it is then carried entirely by thread *a*. It will be noted from this diagram that the line of contact between the worm-tooth

[2] See THE JOURNAL, April, 1921, p. 350.

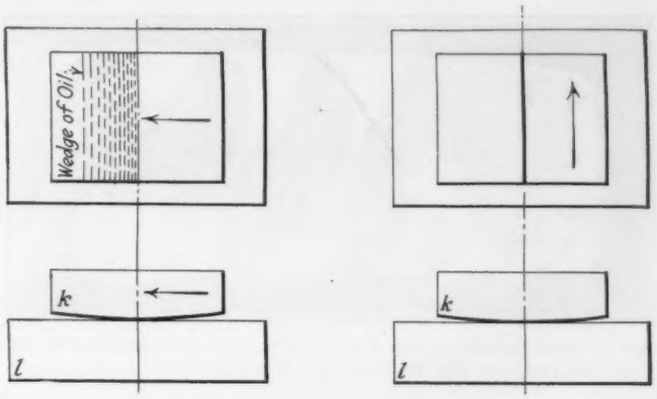


FIG. 7—DIAGRAM SHOWING THE EFFECT OF SHAPE OF CONTACT AREA AND LINE OF MOTION ON LUBRICATION
As the Motion Is in the Direction of the Line of Contact, an Oil-Film Would Get Little Chance To Establish Itself

and the wheel is sensibly parallel to the direction of relative motion of the surfaces. If we consider that an oil-film must be maintained between these surfaces, it will be noted that the motion is such that the oil-film is not distributed by the action of contact.

Fig. 7 shows the block *k* with a cylindrical face resting on the plane block *l*. It will be noted that as the motion at the left is in the direction of the line of contact, an oil-film would get little chance to establish itself.

DEPARTURE FROM INVOLUTE FORM

In Captain Bramley-Moore's paper another form of gearing was studied, in which a radical departure was made from the involute tooth-form. The straight-line generatrix of the worm-thread was still maintained, but it no longer intersects the axis of the worm, making the rack side of the worm-thread. Instead this generatrix is tangent to a cylinder that is approximately the root diameter of the worm. As proved by Captain Bramley-Moore in his paper, the tooth form generated by the new position of the generatrix gives a tooth form that has true angular-velocity in planes other than the central plane.

Fig. 8 shows the general appearance of the tooth shape of this new form of gearing, which is known today as the FJ worm-gear, from the initials of its inventor, F. J. Bostock. It will be noted that the sides of the worm-tooth in this central plane are no longer straight, but are curved, and the tendency of the curve of the wheel is toward the concave, rather than the convex, as it had been in the involute type.

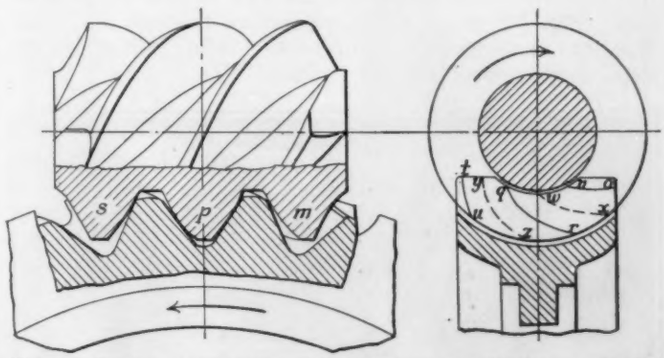


FIG. 8—GENERAL APPEARANCE OF THE SHAPE OF A TOOTH IN THE FJ TYPE OF GEAR
The Sides of the Worm-Tooth in the Central Plane Are No Longer Straight, but Are Curved, and the Tendency of the Curve of the Wheel Is Toward the Concave Rather Than the Convex, as It Had Been in the Involute Type

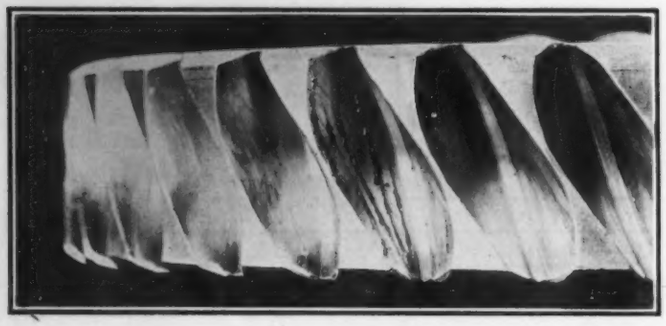


FIG. 9—PHOTOGRAPH OF THE ACTUAL CONTACT OF AN INVOLUTE WORM
This Substantiates the Mathematical Analysis Given in the Paper

A radical change is also noted in the line of contact between the worm and the wheel. Thread *m*, which is about to contact with the wheel, will make its initial contact on line *n-o*. Thread *p*, which is carrying the load, is contacting along the line *q-r*, while thread *s*, which has passed out of contact, had its last area at line *t-u*. As the tooth phase of the gearing progresses, the contact between the thread *m* and the wheel moves forward to line *w-x*, while *p* moves forward to *y-z*.

As distinguished from the involute type, it will be noted that the lines of contact are no longer sensibly circumferential about the worm-axis, but have swung round in a more radical direction; and it will also be noted that the area of contact is progressing in the direction of rotation. This has a profound effect on the lubrication. Referring to the right half of Fig. 7, we have a condition wherein the block *k* is sliding more nearly at right-angles to its line of contact, with the result that a wedge of oil is being fed between the surfaces.

Fig. 9 shows a view of the actual contact of an involute worm that substantiates the mathematical analysis above. Fig. 10 is a view of the tooth contact of an FJ-type gear.

HINDLEY OR HOUR-GLASS TYPE

Possibly some may question why the hour-glass or Hindley type of worm has not been mentioned. This type of worm-gear presents many problems that have prevented its extensive use in automotive practice. Due to the peculiar shape of the worm, it is extremely difficult to generate-grind it and to maintain the high degree of accuracy that is essential in any worm-gear set. Due to the fact that the pitch-line of the worm follows that of the gear, this type of worm will not allow any displacement along its axis, because the displacement immediately changes all the factors of the tooth contact. Fig. 11 shows a normal section through a typical Hindley or hour-glass worm-wheel and the effect of axial displacement on the contact.

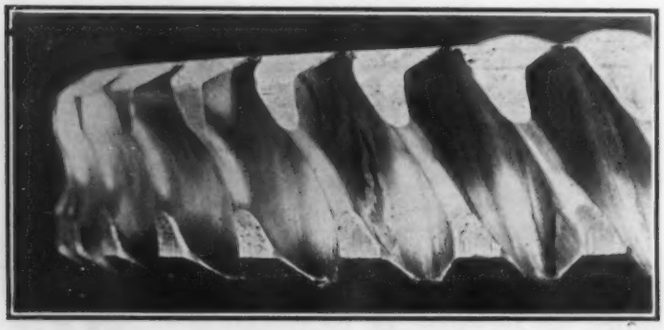


FIG. 10—PHOTOGRAPH OF TOOTH CONTACT IN THE FJ TYPE OF GEAR

A principle of the worm-gear to which in a large measure its natural quietness is due is the fact that the tooth surfaces, as they assume contact, have the maximum obliquity of motion. In other words, they slide into contact rather than roll.

Fig. 12 diagrammatically illustrates this principle, although rather crudely. It will be noted that the motion of the worm about its axis is along the line a_1-b_1, which is oblique to the tangent c_1-d_1 to the worm surface. The result is that the surfaces ease into contact with each other. This is true basically of the worm as distinguished from other types of gearing in which the tooth surfaces roll into contact with each other.

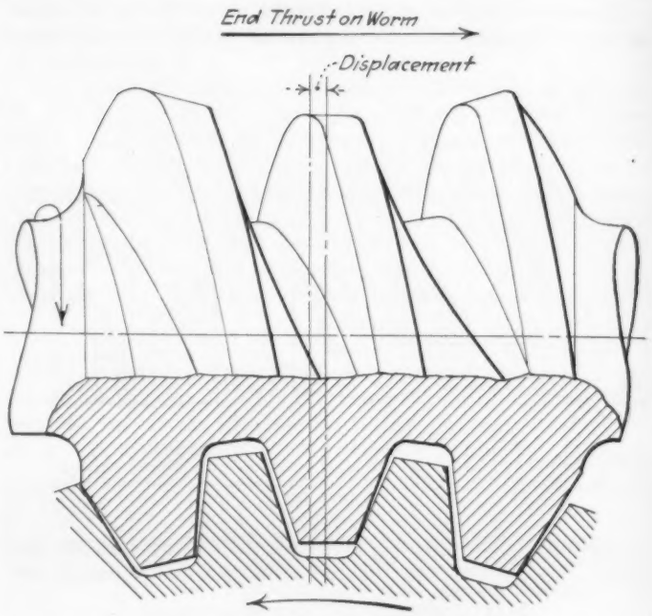


FIG. 11—NORMAL SECTION THROUGH A TYPICAL HINDLEY OR HOUR-GLASS WORM-WHEEL, SHOWING THE EFFECT OF AXIAL DISPLACEMENT ON CONTACT
The Peculiar Shape of the Worm Makes It Extremely Difficult To Generate-Grind and To Maintain the High Degree of Accuracy Essential to a Worm-Gear Set

Fig. 13 illustrates this point. The motion of tooth e_1, which of course is about its axis f_1, is sensibly at right-angles to a tangent g_1-h_1 to the surface of the conjugate tooth with which it is making contact. This tendency toward impact, with its consequent tendency toward noise, is the reason for the development of many varieties of spiral gearing, such as the herringbone and spiral-bevel gearings. The object is to attain as much obliquity of contact as possible and a distribution of the impact of various tooth-phases over as much angular displacement as possible. As these different forms of gearing show this tendency, so do they approach the worm-gear in their ability to transmit power with the minimum of noise. The worm-gear still represents the maximum attainable in this respect.

SALIENT FEATURES OF WORM-GEARING

The recent development of the motorcoach has brought out many salient features that the worm-gear possesses. The first is that it is an inherently silent form of final-drive. The second is that it retains its silence throughout its life. Records of mileages with one set of gearing of 500,000 miles are common. Fig. 14 is a view of a worm-gear that has run 300,000 miles. It can be seen from the photograph that this gear is good for many

more miles. The owner, who operated the motorcoach from which this set was removed, was given a new set of gearing so that we might have this particular gear-set for study. It is an authentic record of worm-gear life and the possible mileage that may be obtained.

The third advantage that the high speeds and heavy loads of the motorcoach brought out was that the worm-gear is able to resist shock loads without damage. The resultant forces reacting on the bearings of a worm-gear set are such that no displacement tending to throw the tooth surfaces out of contact or out of mesh occurs. In other words, the loads on the bearings supporting the worm-wheel are in the same direction, while, in a bevel-gear, the loads on the bearing supporting the ring gear are reversed on one side as compared with the other. This tends to displace the ring gear and force it out of mesh with the pinion. The ability to stand excessive shock-loads has allowed the use of a propeller-brake in front of the worm-drive, for either foot brake or hand brake needs, whereas the application of such a brake in front of any other form of gearing has, in most cases, proved impracticable, except for use as a parking-brake.

The fourth advantage is brought out in the manufacture of worm-gearing. By its very nature, the worm-tooth contours may be ground, that is, the tooth surfaces

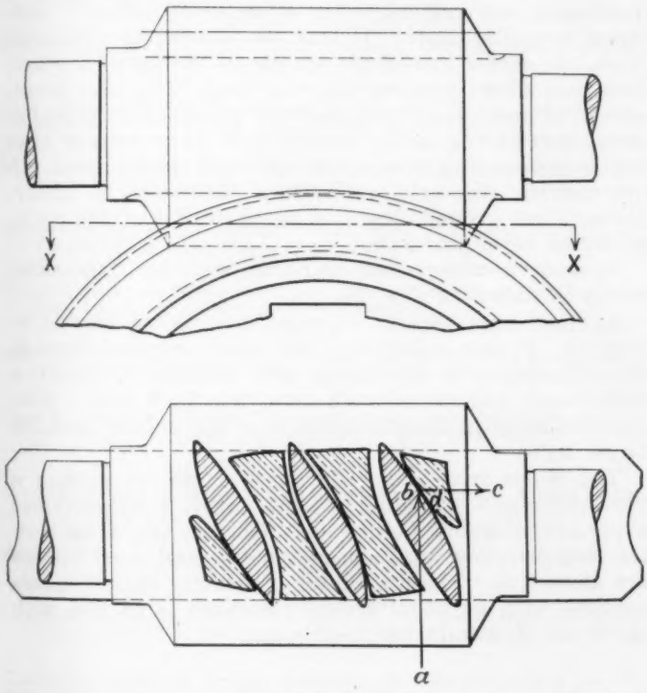


FIG. 12—ILLUSTRATION OF THE OBLIQUITY OF ENGAGEMENT OF WORM-GEARING
The Surfaces Ease into Contact with Each Other, a Distinguishing Feature of Worm-Gearing As Compared with Tooth Surfaces

can be generated with a grinding-wheel after all such operations as heat-treating, carburizing, and the like, have been performed.

ACCURACY OF TOOTH PROFILE, LEAD-ANGLE AND SPACING

Consequently, a finished worm-gear can be produced, in which an extremely high degree of accuracy of tooth profile, lead-angle and tooth spacing can be maintained. This fact is very important, because it should be remembered that the worm-tooth surfaces constitute the surfaces traced by the generatrix for both the worm-thread and the wheel-tooth surfaces. It can therefore be seen that, if the worm is held very close to the theoretically perfect

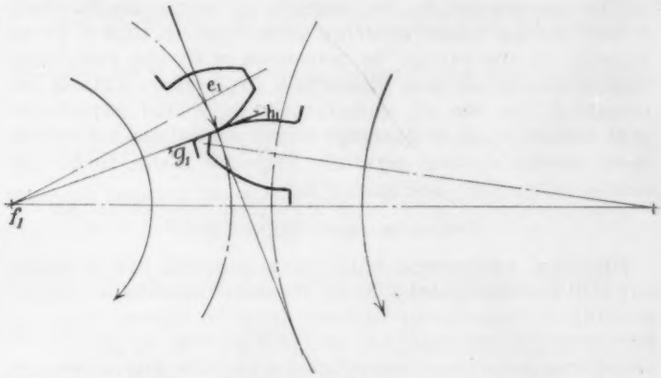


FIG. 13—ILLUSTRATION OF THE OBLIQUITY OF CONTACT OF OTHER TYPES OF GEARING
Tendency toward Impact with the Resultant Noise Has Led to the Development of Many Varieties of Spiral Gearing

form, it will generate, as wear occurs, theoretically correct surfaces on the worm-wheel teeth. In other words, wear, as it occurs in the worm-gear set, does not cause the tooth surfaces to depart from the theoretical value aimed at when they were cut but actually tends to continue generating theoretically correct surfaces. In fact, if a worm that is correct is run with a wheel that has slightly false tooth-contact, the wear immediately seeks to modify the imperfections of the worm-wheel teeth and to bring them toward the correct values. This is true only of the worm-gear, as the tendency in all other types of gearing is for wear to destroy the tooth contours originally cut. This peculiarity of worm-gearing is the reason that the worm, which is really the generatrix, is made of a material to which the maximum possible surface-hardness and polish can be given. The wheel, on the other hand, is made of a material that has the maximum amount of the desirable properties of a bearing-metal that can be obtained with the necessary amount of physical strength.

FIG. 14—WORM-GEAR THAT HAS RUN FOR 300,000 MILES
The Owner Who Operated the Motorcoach from Which This Set Was Removed Was Given a New Set of Gearing in Order That This Particular Set Might Be Available for Study

The worm-gear, by its property of being silent, offers a very strong manufacturing advantage in that a given number of pieces can be processed with the assurance that they will all pass inspection for noise. This is interesting, for we all undoubtedly have had experience with other types of gearing, which sometimes seem, the more accurately and carefully they are made, to be the noisier when they are assembled.

Freedom from Knocking

Practical experience with worm-gearing has brought out still another point. In all forms of gearing a certain amount of clearance or backlash must be allowed between the teeth, to provide for an oil-film and to allow for slight inaccuracies of manufacture and the displacements due to load. This has been held down to as small a limit as possible, because it was found to give a knock, due to torque reversal, especially at low vehicular-speeds. The worm-gear, due to the obliquity of the approach of the teeth has not a tendency to knock because of torque reversal, which undoubtedly is due to the obliquity of the surfaces, the greater areas in contact, and the low resonant-qualities of the materials.

The passenger automobile, during the period of development of the motorcoach, had been undergoing a similar development. The tendency in designing passenger automobiles has been toward the maximum of comfort and the greatest possible speed consistent with safety. There is a demand for the utmost operating quietness. The speed requirement has brought out the importance of proper distribution of weight and especially of keeping the center of gravity as low as possible. When maximum car-speeds were 40 m.p.h., the height of the center of gravity of the car was not so important as it is today, when speeds of 60, 70 or even 80 m.p.h., are expected. The high performance factors demanded of present-day automobiles are also having their effect. Today a car is expected to stop as quickly as modern traffic-conditions demand. A low center of gravity tends to minimize the effect of weight transfer from the rear to the front wheels and to stabilize the car when an extreme braking-condition is encountered.

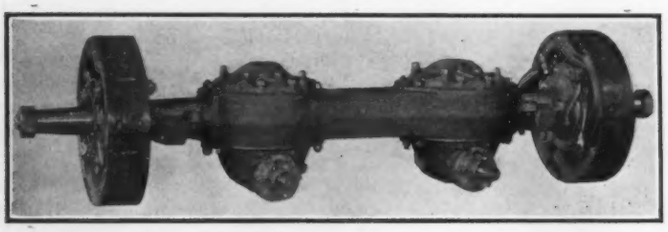


Fig. 15—Modern Motorcoach Rear Axle with Underslung Worm

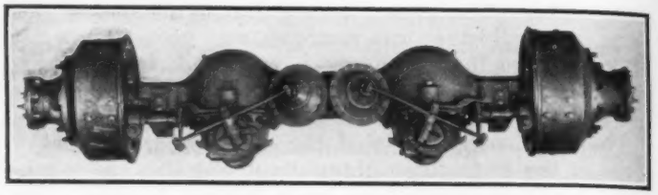


Fig. 16—Another Motorcoach Rear Axle with Underslung Worm
This Axle Is Similar to That Shown in Fig. 15, Except in Size

Solution of Problem of Final-Drive

The bevel-gear as a final-drive imposed a limit on how low a passenger automobile could be built, because the axis of the pinion intersects the axis of the gear; and the axis of the pinion, of course, determines the position of the propeller-shaft. The position of the propeller-shaft, in turn, limited designers in their desire to make a low chassis. To gain the desired low effect, head-room and comfort have been restricted. It is only natural, therefore, to turn to all that has been learned about the worm-drive in developing the modern motorcoach for a possible solution of the problem of the final-drive for passenger automobiles. The worm-drive allows a low-hung propeller-shaft. It has the minimum dimension from the center-line of the wheels to the top of the axle and thus allows lowering the rear seat. The high horsepower of motorcoach engines has proved that a worm-drive axle having safety factors equal to or greater than the corresponding bevel-drive axle can be designed. A worm-drive rear-axle, even when the worm is underslung, gives ground clearance equal to that of the corresponding bevel-gear axle.

A modern motorcoach rear-axle with an underslung worm is shown in Fig. 15.

Another motorcoach worm-drive axle is shown in Fig. 16. In this axle, every advantage acquired through the experience of developing and building worm-drive motorcoach and motor-truck axles has been used. Note the similarity in the construction of the smaller and the larger axles.

The worm-drive axle, of course, costs more than a bevel-drive axle of similar capacity. But it certainly has many advantageous features to offset the additional cost. Its long life, low up-keep, simplicity, and dead silence are attractive. The low center of gravity that it makes possible with an equal ground-clearance is in line with the trend of chassis design of today.

Applicants *Qualified*

The following applicants have qualified for admission to the Society between April 10 and May 10, 1926. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member.

ALLEN, HENRY BUTLER (A) chief metallurgist, Henry Disston & Sons, Inc., *Tacony, Philadelphia.*

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ASPELL, THOMAS A. (A) salesman, B. F. Goodrich Rubber Co., *Akron, Ohio.*

BACHMANN, JOSEPH E. (A) motor-truck fleet owner, Coolidge Point, *Magnolia, Mass.*

BARNETT, L. M. (A) retail sales manager, General Motors Truck Co., 515 Van Ness Avenue, *San Francisco.*

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CANALI, FREDERIC (M) draftsman and designer in engineering laboratory, Ford Motor Co., *Dearborn, Mich.;* (mail) 429 Park Street West.

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COOKE, HARTE (M) engineer, McIntosh & Seymour Corporation, *Auburn, N. Y.;* (mail) 10 Jefferson Street.

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DAVIS, RAYBERN W. (A) Detroit manager, A. Schrader's Son, Inc., Brooklyn, N. Y.; (mail) 5-209 General Motors Building, *Detroit.*

DE CAMP, RALPH D. (A) president, Royal Motor Coach Co., Inc., Rahway, N. J.; president, general manager, De Camp Bus Lines, Inc., Livingston, N. J.; (mail) Livingston Avenue, *Livingston, N. J.*

DRAKE, L. P. (M) president, J. A. Drake & Sons, Inc., *Reedley, Cal.*

EDSON, FRANKLIN C. (A) president, Asbestos Mfg. Co., 40 West 40th Street, *New York City.*

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Drake, Frank G., advertising manager.
Searls, Bert C., salesman.

EITEL, WILLIAM C. (S M) airplane inspector, Air Service Procurement Section, *New York City;* (mail) 600 West 174th Street.

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Representatives: Brookes, William, president and treasurer.
Dodge, W. C., Jr., vice-president and secretary.

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MERZ, CHARLES C. (A) assistant to president, H. C. S. Cab Mfg. Co., 14th Street and Capitol Avenue, *Indianapolis.*

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SHOEMAKER, L. F. (A) assistant Eastern sales manager, Buda Co., Harvey, Ill.; (mail) 30 Church Street, *New York City.*

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SMITH, JAMES (F M) chief engineer, Vacuum Oil Co., *Bombay, India.*

SMITH, M. A. (A) president, McKee Glass Co., *Jeannette, Pa.*

STAUB, CHARLES R. (M) gear specialist, Ford Motor Co., 2354 Tuxedo Avenue, *Detroit.*

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STIRLING, A. BRUCE (M) in charge of engineering, Wills Sainte Claire, Inc., *Marysville, Mich.*

SUSSIN, VICTOR (J) engineer, Stewart-Warner Speedometer Corporation, *Chicago;* (mail) 632 Oakdale Avenue.

THOMSON, NORMAN A. (M) engineer, Hayes Wheel Co. of Canada, Ltd., *Chatham, Ont.,* Canada; (mail) 136 William Street, North.

THUNER, ROBERT (A) sales manager, O. & S. Bearing Co., 303 South Artillery Avenue, *Detroit.*

UNDERHILL, GEORGE S. (A) service manager, Durant Motors, Inc., *Lansing, Mich.*

UNITED STATES ASBESTOS CO. (Aff) *Manheim, Pa.*
Representative: Wild, R., manager of sales to manufacturers, Detroit.

VOORHEES, H. R. (J) assistant engineer, United Motors Products Co., *Grand Rapids, Mich.;* (mail) 751 Paris Avenue.

WALLACE, JOHN FRANK (M) chief engineer of automotive division, Cleveland Pneumatic Tool Co., 3734 East 78th Street, *Cleveland.*

WELLS, JAY L. (A) supervisor of inspection, Olds Motor Works, *Lansing, Mich.;* (mail) Porter Apartments.

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WILLIAMSON, JOHN D. (A) district sales manager, S K F Industries, Inc., 165 Broadway, *New York City.*

WILSON, COMMANDER EUGENE EDWARD (S M) head of engine section, bureau of aeronautics, Navy Department, *City of Washington.*

WOLCOTT, KENNETH O. (A) assistant general manager, North East Service, Inc., *Rochester, N. Y.*

WOODWARD, W. S. (A) technical service representative, United States Rubber Co., Fifth and Locust Streets, *Philadelphia.*

WOODWORTH, ERNEST H. (J) tester, Boston Overland Co., Boston; (mail) 120 Church Street, *Newton, Mass.*

WYANT, I. A. (A) secretary and treasurer, Campbell, Wyant & Cannon Foundry Co. *Muskegon, Mich.*

WYATT, M. E. (A) president and manager, Wyatt Auto Equipment Co., Inc., *Nashville, Tenn.;* (mail) 809 Fatherland Street.

YETTER, OTTO M. (J) draftsman, A. M. Wolf, *New York City;* (mail) 727 East 152nd Street.

ZEITFUCHS, EDWARD H. (M) research engineer, Standard Oil Co. of California, *Richmond, Cal.*

ZUCROW, MAURICE J. (M) research assistant, Purdue University, Lafayette, Ind.; (mail) 618 Evergreen Street, *West Lafayette, Ind.*

Applicants *for* Membership

The applications for membership received between April 15 and May 15, 1926, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALLIASON, LAWRENCE B., gear specialist, Ford Motor Co., *Detroit.*

ANDERSON, H. W., purchasing agent, Everett W. Cox Co., *Jersey City, N. J.*

BACON, W. WARDER, JR., assistant to electrical engineer, Autocar Co., *Ardmore, Pa.*

BEACH, CLARENCE H., steel sales agent, *Indianapolis.*

BEAL, W. HUBERT, sales manager, Lycoming Mfg. Co., *Williamsport, Pa.*

BELYANTCHIKOFF, P. M., professor of mechanical engineering, Agricultural Academy of Timiryazeff, *Moscow, Russia.*

BENFORD, FRANK, physicist, General Electric Co., *Schenectady, N. Y.*

BOHLTER, LLEWELLYN, assistant professor of experimental engineering, University of California, *Berkeley, Cal.*

BRIGHT, THOMAS C., manager of tubing sales, Rome Mfg. Co., *Rome, N. Y.*

BRITTEN, E. F., JR., vice-president, Monroe Calculating Machine Co., *Orange, N. J.*

BROWN, LEE R., chief designer, Monroe Calculating Machine Co., *Orange, N. J.*

BUSHEY, J. S., owner, J. S. Bushey Co., *Los Angeles.*

CLARKE, JOSEPH G., sales engineer, Dayton Engineering Laboratories Co., *Dayton, Ohio.*

COLLIER, CLIFFORD M., installing cost system, Cleveland Railway Co., *Cleveland.*

COLWELL, A. T., sales engineer, Steel Products Co., *Detroit.*

CONLEY, A. W., vice-president and general manager, Butler Mfg. Co., *Cleveland.*

CONLEY, J. D., production manager, Butler Mfg. Co., *Cleveland.*

CULTICE, W. A., experimenting, Buda Co., *Harvey, Ill.*

DE BELL, GEORGE W., stress analyst, Huff-Daland Airplane Co., *Bristol, Pa.*

DE GIULIANI, H., engineer, E. A. Rockwell Laboratory, *Long Island City, N. Y.*

DELAGE, PIERRE, engineer, Delage et Cie, *Courbevoie (Seine), France.*

ENGELMANN, OTTO, senior administrative officer, Bureau of Public Roads, *City of Washington.*

FAIREY, CHARLES R., chairman, Fairey Aviation Co., Ltd., *Hayes, Middlesex, England.*

FAY, E. F., superintendent and partner, Doane Motor Truck Co., *San Francisco.*

FERGUSON, JOHN C., general manager, Eclipse Machine Co., *Elmira, N. Y.*

FRANK, G. C., district service manager, White Co., *Dallas, Tex.*

GAULTIER, MAURICE, chief engineer, Delage et Cie, *Courbevoie (Seine), France.*

GIBSON, ROBERT H., engineer's assistant, American Bosch Magneto Corporation, *Springfield, Mass.*

GOLLER, G. O., body engineer, Luxor Cab Mfg. Corporation, *Framingham, Mass.*

GRAICHEN, RALPH R., aeronautical engineer, Ford Motor Co., *Dearborn, Mich.*

GREENLEES, JAMES, foreman, Kissel Motor Car Co., *Hartford, Wis.*

GROGAN, LEO V., assistant to assistant sales manager, Studebaker Corporation of America, *South Bend, Ind.*

HAAS, FELIX, tool designer, Climax Engineering Co., *Clinton, Iowa.*

HADLEY, FRANK, draftsman, International Motor Co., *Long Island City, N. Y.*

HARRELL, E. R., general factory manager, Graham Bros., *Detroit.*

HATCH, CHARLES B., manager of department of passenger transportation, Mack-International Motor Truck Co., *Philadelphia.*

HERRON, OLLIE L., president, Herron-Zimmers Moulding Co., *Chicago.*

HEWITT, ASHLEY C., rail-car engineer, International Motor Co., *New York City.*

HINZ, WALTER H., draftsman, Wisconsin Motor Mfg. Co., *Milwaukee.*

HOEHN, RUDOLPH W., special service representative, White Co., *Cleveland.*

HUISH, E. H., assistant manager, Ford Motor Co., *City of Washington.*

HURTGEN, ARCHIBALD, metallurgical laboratory, Continental Motors Corporation, *Muskegon, Mich.*

IRVINE, J. S., Western sales manager, Taft-Peirce Mfg. Co., *Woonsocket, R. I.*

IRVINGTON VARNISH & INSULATOR CO., *Irvington, N. J.*

KING, HAROLD MCCULLOUGH, laboratory assistant, White Motor Co., *Cleveland.*

KNAPTON, FRANCIS, experimental engineering, Rolls-Royce of America, *East Springfield, Mass.*

LAIDLAW, ELMER A., foreman of erecting and repair floor, Oakland Motor Co., *Pontiac, Mich.*

LAPSLEY, ROBERT, chief engineer, Detroit Gear & Machine Co., *Detroit.*

LEONARD, H. R., JR., vice-president, Watson Stabilator Pacific Co., *San Francisco.*

LUND, BART, draftsman, Cadillac Motor Car Co., *Detroit.*

MCCUE, JAMES O., general manager, Stamford Rolling Mills Co., *Springdale, Conn.*

MCCUTCHEON, WILLIAM A., superintendent of automobile department, West Penn Power Co., *Pittsburgh.*

MCMAHON, HERBERT A., production engineer, Oil Well Supply Co., *Oil City, Pa.*

MALIVERT, JULES EUGENE, technical director, Societe des Appareils, *Paris, France.*

MARTINEK, ALOIS LOUIS, electrical engineer, Ford Motor Co., *Dearborn, Mich.*

MARVIN, FRED, chief engineer, General Motors Truck Corporation, *Detroit.*

MASON, WENDELL E., instructor, Southern branch, University of California, *Los Angeles.*

MAUK, BENJAMIN FRANKLIN, superintendent, Fort Dearborn Mfg. Co., *Rock Falls, Ill.*

MELIA, JOSEPH H., service manager, Sterrett & Co., *City of Washington.*

MELOON, NATHANIEL W., vice-president and general manager, Buffalo Bronze Die Casting Corporation, *Buffalo.*

MIGNOT, ARTHUR E., department manager, Irvington Varnish & Insulator Co., *Irvington, N. J.*

MULCHAY, CHARLES T., machinist, Bethlehem Shipbuilding Co., *San Pedro, Cal.*

NEELY, WILLIAM H., director of engineering, Graham Bros., *Detroit.*

NYROP, MICHAEL, designing engineer, Brooks Steam Motors, Ltd., *Stratford, Ont., Canada.*

OLSON, C. R., sales promotion manager, Skelly Oil Co., *Kansas City, Mo.*

OVAITT, DAVID W., efficiency engineer, Buick Motor Co., *Flint, Mich.*

OWENS, THOMAS, superintendent of maintenance, Cleveland Railway Co., *Cleveland.*

PARKIN, J. H., assistant professor of mechanical engineering, University of Toronto, *Toronto, Ont., Canada.*

PAXTON, CHARLES H., instructor, Southern branch, University of California, *Los Angeles.*

PFEIFFER, KARL, mechanical engineer, Chrysler Motor Corporation, *Detroit.*

POVLSEN, PAUL K., engineer, New York Telephone Co., *New York City.*

RAMSEY, J. A., president, Ramsey Accessories Mfg. Corporation, *St. Louis.*

REID, EARL, development engineer, Manhattan Rubber Mfg. Co., *Passaic, N. J.*

ROBERTS, CAREY R., engine man, aircraft department, Packard Motor Car Co., *Detroit.*

ROCHE, EDWARD G., foreman, Durant Motor Co. of California, *Oakland, Cal.*

ROGERS, WALTER S., assistant repair service engineer, White Co., *Cleveland.*

ROLFING, R. C., works manager, Hart-Parr Co., *Charles City, Iowa.*

ROOD, WARREN B., sales manager, Herron-Zimmers Moulding Co., *Detroit.*

ROSE, C. R., service manager, Carlyle Nibley, Inc., *Long Beach, Cal.*

SCHUETZ, THOMAS J., chief engineer, Braden Steel & Winch Co., *Tulsa, Okla.*

SERGAYEFF, BORIS P., design engineer, Reo Motor Co., *Lansing, Mich.*

SHIELDS, WILLIAM, tool engineer, Indian Motocycle Co., *Springfield, Mass.*

SOEHNER, HOWARD C., experimental engineer, Brooks Steam Motors, Ltd., *Stratford, Ont., Canada.*

SPOONER, F. P., engineer of tests, Bethlehem Steel Co., *Bethlehem, Pa.*

SPRIGGS, ERNEST L., vice-president in charge of operations, Rome Mfg. Co., *Rome, N. Y.*

STEARNS, RUSSELL, aviation mechanic, H. J. Wells, *Worcester, Mass.*

STEIN, E. WALDO, special representative, Firestone Tire & Rubber Co., *Akron, Ohio.*

STOVER, P. A., president and general manager, Stover Signal Engineering Co., *Racine, Wis.*

STROBEL, LUTHER WILLIAM, salesman, Sterrett & Co., Inc., *City of Washington.*

STURROCK, JAMES, JR., mechanical and metallurgical engineer, Ingersoll-Rand Co., *Athens, Pa.*

TAYLOR, KENNETH E., assistant service manager, Western Machinery Co., *Los Angeles.*

TROTH, E. A., assistant district manager, Richfield Oil Co., *San Francisco.*

TROXELL, GEORGE B., research engineer, Bethlehem Steel Co., *Bethlehem, Pa.*

TUNISON, DWIGHT E., manager of parts department, Lynn C. Buxton, *Los Angeles.*

TURNER, EARL, manager, Automotive Electric Association, *Cleveland.*

VANDERVEER, HERBERT E., designing and inventing, Ignition & Battery Service, Pueblo, Col.; Automatic Oil Heating Co., *Denver, Col.*

VON HAMBACH, E., director of sales and engineering, Boyle Valve Co., *Chicago.*

WALTHER, C. M., research engineer, Moon Motor Car Co., *St. Louis.*

WARD, GEORGE LEOPOLD, research engineer, Standard Oil Co. of New Jersey, *Elizabeth, N. J.*

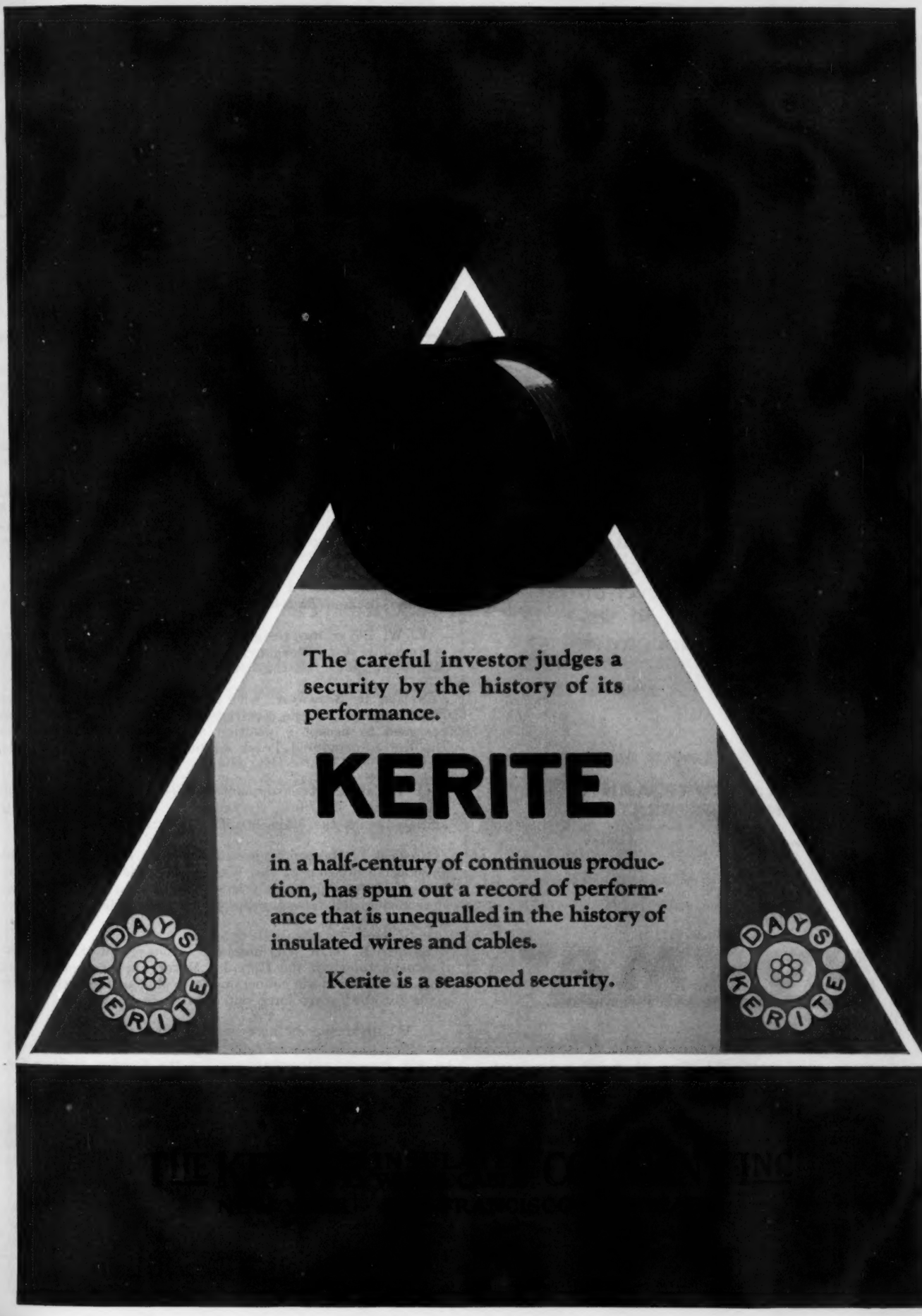
WARREN, GEORGE HENRY, JR., stock broker, New York Stock Exchange, *New York City.*

WATSON, THOMAS A., designing engineer, University of California, *Los Angeles.*

WEED, ROBERT F., sales manager of automotive division, American Cable Co., Inc., *New York City.*

WILLI, A. B., executive engineer, Continental Motors Corporation, *Detroit.*

ZIELSKI, VICTOR, body draftsman, Flint Motor Co., *Flint, Mich.*


The careful investor judges a security by the history of its performance.
KERITE
in a half-century of continuous production, has spun out a record of performance that is unequalled in the history of insulated wires and cables.
Kerite is a seasoned security.
DAYS KERITE
DAYS KERITE

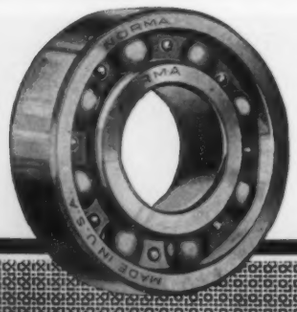
OPEN TYPE

"NORMA"

Fifteen years have wrought many changes in the automotive industries—but not in the standards of quality which have made "Norma" Precision Bearings an ever-increasing factor in stabilizing car and truck performance.

NORMA-HOFFMANN BEARINGS CORPORATION
Stamford — Connecticut
PRECISION BALL, ROLLER AND THRUST BEARINGS

"NORMA"



CLOSED TYPE

Personal Notes of the Members

Items regarding changes in business connections, promotions, etc., are desired from the membership for insertion in these columns. This will enable members to keep their friends informed of their whereabouts and will also assist in keeping the records of the Society up to date.

Stanley C. Allen, who was formerly in the dynamometer laboratory of the Reo Motor Car Co., Lansing, Mich., is now vice-president and general manager of the Stanley Allen Co., Inc., of that city.

A. E. W. Babington has severed his connection with the W. B. Deyo Co., Detroit, where he was salesman. No announcement has been made concerning his future plans.

W. Burr Bennett, who until recently was production manager of the Bloomfield, N. J., plant of the American La France Fire Engine Co., Elmira, N. Y., is now associated with the Maccar Truck Co., Scranton, Pa.

Irving H. Bernard has been appointed manager of sales for the Indiana Distributors, Inc., Long Island City, N. Y.

V. W. Boyer has resigned as designer for the Cleveland Automobile Co., Cleveland, and is now affiliated with the White Motor Co., of that city, in a similar capacity.

Nelson R. Brownyer, who for the last 5 years has been chief engineer of the Gotfredson Corporation, Detroit, has resigned to accept a position as motorcoach engineer for the Kelly-Springfield Truck & Bus Corporation, Springfield, Ohio.

C. A. Call has been appointed sales manager of the Rollway Bearing Co., Inc., Syracuse, N. Y. He was formerly affiliated with the Ohio Insulator Co., Barberton, Ohio.

Howard L. Davis has joined the sales department of the automotive division of the Wagner Electric Corporation, St. Louis. He was previously sales engineer in charge of road engineering and sales for the Connecticut Telephone & Electric Co., Meriden, Conn.

Edward E. Dean, who has been in charge of the specification department of the Hercules Motor Corporation, Canton, Ohio, has severed his connection with that organization. His plans for the future have not been made known.

J. H. Dickinson is now service manager for the Mills Novelty Co., Chicago. Prior to establishing this connection he was general sales manager for the Fairfax Rubber Co., also of Chicago.

C. B. Dicksee, section engineer in the small motor engineering department of the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., has severed his connection with that company and has returned to Europe. He will be located in London for the present.

A. L. Doerr has become affiliated with the General Motors Truck Co., Detroit. He was previously Pacific coast representative with headquarters in San Francisco, for the Yellow Cab Mfg. Sales Corporation, Chicago.

(*Continued on p. 20*)

Check These Ten Big Smith Wheel Features:—

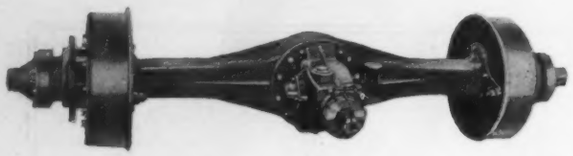
STRENGTH
BEAUTY
TIRE ECONOMY
DISTINCTIVENESS
ACCESSIBILITY
CHARACTER
PERMANENCE
ONE-PIECE DESIGN
SAFETY
SALES APPEAL

All of these fine points of desirability are exclusively a part of and synonymous with this great product of a great manufacturing organization.

The Smith Wheel brings character to your product, be it a big, beefy truck, or the finest of motor cars.

The Smith Wheel has genuine sales appeal. It is a reflection of in-built quality. It is a visible indication of a well-built product. It helps to solve the dealer's selling problem, and this, when competition is the order of the day, is not to be scorned.

SMITH WHEEL INC.
SYRACUSE, N.Y.
Established 1845



WISCONSIN AXLES

FOR

TRUCKS, COACHES, RAIL CARS, GAS-ELECTRICS

Unfailing dependability has stamped Wisconsin Axles a leader in their field. All that is best in the science and knowledge of automotive engineering is embodied in their design: one piece cast housing extending from wheel to wheel; triple heat treated shafts; double heat treated gears; nickel steel differential internal parts; drop forged differential cases and four separate oversize brakes located in the wheels.

Wisconsin Axles are identified with some of the finest trucks and buses produced in this country. Their superiority has earned recognition from designers who have had years' of experience with various other makes and types of final drive; they are universally accepted by fleet owners acquainted with the trouble free service they render.

Standardize on Wisconsin Axles. A complete line of types and sizes is available for every purpose—for trucks ranging from 1 to 7 tons and for buses seating from 15 to 60 passengers.

If you are buying axles for commercial vehicles or if you are an operator, we have interesting information for you, that will enable you to improve your product or decrease your costs.

Wisconsin Parts Co.
OSHKOSH, WIS.

WISCONSIN AXLES

PERSONAL NOTES OF THE MEMBERS

Continued

Edward A. Field has resigned as president of the Field Engineering Co., Chicago. No announcement has been made regarding his future plans.

R. J. Fitness, who for the last 3 years has been connected with the engineering department of the Chrysler Corporation, Highland Park, Detroit, is now sales engineer for the Belflex Corporation, New York City.

At a recent meeting of the board of directors of the Gabriel Snubber Mfg. Co., Cleveland, **Claude H. Foster** was elected chairman of the board. He will be succeeded as president by **George H. Ralls**, who was formerly vice-president and general manager. **David Benjamin** was reelected secretary.

A. H. Gfrorer, who was until recently factory manager for the Kodel Radio Corporation, Cincinnati, has returned to his former position as chief engineer of the Automatic Transportation Co., Buffalo.

Howard B. Haskins has been appointed experimental engineer for the Dura Co., Toledo. He was previously engaged as body engineering checker for the Packard Motor Car Co., Detroit.

Howard W. Henry, who was formerly assistant to the chief engineer of the Shaw Insulator Co., Irvington, N. J., has been appointed sales engineer for Frigidaire refrigerators for the Delco-Light Co., Dayton, Ohio.

V. W. Hewlett has joined the engineering department of the American La France Fire Engine Co., Elmira, N. Y. Prior to establishing this connection he was designer for the Indian Motocycle Co., Springfield, Mass.

Russell Huff has severed his connection with Dodge Bros., Detroit, where he was director of engineering. His plans for the future have not been made known.

A. G. Laas, who was until recently the Locomobile Company's representative at the Continental Motors Corporation, Muskegon, Mich., is now service representative for the Locomobile Co. of America, Bridgeport, Conn.

I. Enos Larkin has resigned as service engineer for the Philbrin Corporation, Kennett Square, Pa., to become instructor in automotive equipment for the Link-Belt Co., Indianapolis.

O. P. Liebreich, designer of the American Tilling-Stevens gasoline-electric motorcoaches, has resigned as chief engineer of the American National Omnibus Corporation, Detroit. No announcement has been made regarding his future plans.

Paul W. Litchfield was recently elected president of the Goodyear Tire & Rubber Co., Akron, Ohio. He was previously vice-president and factory manager.

Frank J. Lucas has organized the Lucas Engineering Co., Racine, Wis. He was formerly engine designer for the Willys-Overland Co., Toledo.

David S. Ludlum has severed his connection with the Autocar Co., Ardmore, Pa., of which he was president. His plans for the future have not been announced.

Clarence E. Mason has accepted a position as student engineer with the Illinois Glass Co., Alton, Ill. He previously attended the University of Illinois, Urbana.

Charles Meder has sold his interest in the Witherbee Storage Battery Co., New York City, of which he was vice-president and treasurer, and has become president of the United Battery Separator Corporation, also of New York City.

Philip O. Miller has severed his connection with the Robert Bosch Magneto Co., Inc., New York City, where he was engaged as assistant manager of the Chicago branch. No announcement regarding his future plans has been made.

Harry E. Norwood has been made general manager of Norwood Autocraft, Inc., New York City.

(*Concluded on p. 22*)

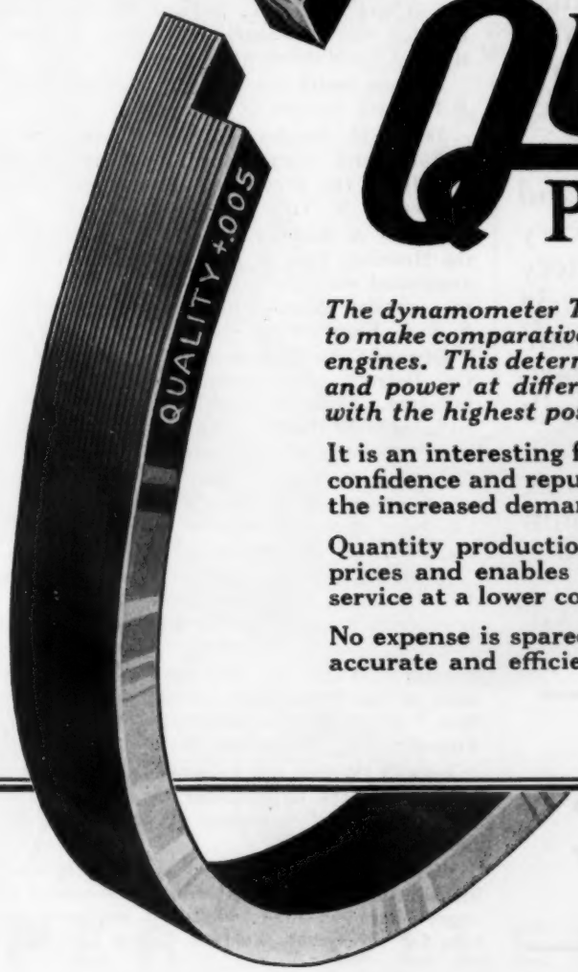
QUALITY
Piston Rings

The dynamometer Testing Laboratory enables our engineers to make comparative tests of piston rings in various makes of engines. This determines time required to seat, compression and power at different speeds and protects our customers with the highest possible quality.

It is an interesting fact that users of piston rings are buying confidence and reputation and this is largely responsible for the increased demands for Quality Brand Rings.

Quantity production (1,000,000 weekly) naturally regulates prices and enables us to give better piston ring value and service at a lower cost.

No expense is spared in research and equipment to produce accurate and efficient rings.



The Piston Ring Company

Muskegon, Michigan

Those Lights in the Train

Storage batteries—in a great many cases, they're Exides—provide the current that illuminates your Pullman berth whenever you switch on the lights. Generators, attached to the car axle, keep them charged.

Built into every Exide—and they are designed for every purpose where storage battery power can be used—is the 38 years' experience of this company. That is why the starting and lighting battery built for any particular car, combines in a unit of given size and weight, the maximum cranking ability.

The Electric Storage Battery Co.
Philadelphia

In Canada, Exide Batteries of Canada, Limited
153 Dufferin Street, Toronto

Exide
BATTERIES

PERSONAL NOTES OF THE MEMBERS

Concluded

Michael Muller has been transferred from the Chicago branch of the Vacuum Oil Co., where he was automotive lubrication sales engineer, to the commercial car division at Indianapolis, as lubrication engineer.

Fred Neale has resigned as chief engineer of the engine division of the General Motors Truck Co., Detroit, and is now technical engineer of the Christensen Air Brake Co., Cleveland.

A. M. Ney, who was until recently designer and builder of motor cars for the European Motor Service, New York City, has accepted a position as chassis designer for the Bragg-Kliesrath Corporation, Long Island City, N. Y.

E. F. Norelius is now affiliated with the Monarch Tractors Corporation, Springfield, Ill. Prior to establishing this connection he was automotive engineer in the Ordnance Department and was stationed at the Rock Island Arsenal, Rock Island, Ill.

A. G. Norris, who was formerly New England manager for the Strom division of the Marlin-Rockwell Corporation, Chicago, has been appointed to a similar position for the Timken Roller Bearing Co., Canton, Ohio. He will maintain an office in Boston.

Louis F. Pietz is now affiliated with the International Harvester Co. of America, Akron, Ohio, at its Springfield, Ohio, works. Until recently he was field engineer for the Bendix Brake Co., South Bend, Ind.

G. J. Rackham has been appointed chief engineer for the Leyland Motor Co., Leyland, Lancashire, England. He was previously chief engineer for the Yellow Truck & Coach Mfg. Co., Chicago.

Andre Reynaud, who was until recently metallurgist for the Inland Steel Co., Indiana Harbor, Ind., has accepted a position as open-hearth inspector for the Armco International Co., Middletown, Ohio.

R. Leon Smith has become affiliated with the American Car & Foundry Motors Co., Detroit.

James H. Snyder is now associated with the Brockway Motor Truck Corporation, Cortland, N. Y. He was previously in the production department of the Pfaudler Co., Rochester, N. Y.

Harold A. Soulis has accepted a position as designer with the Honolulu Iron Works, Brooklyn, N. Y. He was formerly associated with the International Motor Co., New York City, in a similar capacity and latterly was chief engineer of the S. & A. Engineering Works, Nazareth, Pa.

Edward C. Sullivan is now affiliated with the Rinshed-Mason Co., Detroit, in the capacity of salesman to the automotive industry. Prior to establishing this connection he was associated with the Flint Varnish & Color Works, Flint, Mich., in the capacity of sales engineer.

Stephen R. VandeWater, who was formerly vice-president and treasurer of the Penn State Oil Co., Inc., Ossining, N. Y., has been appointed district manager for the Foremost Oil Co., Inc., also of Ossining.

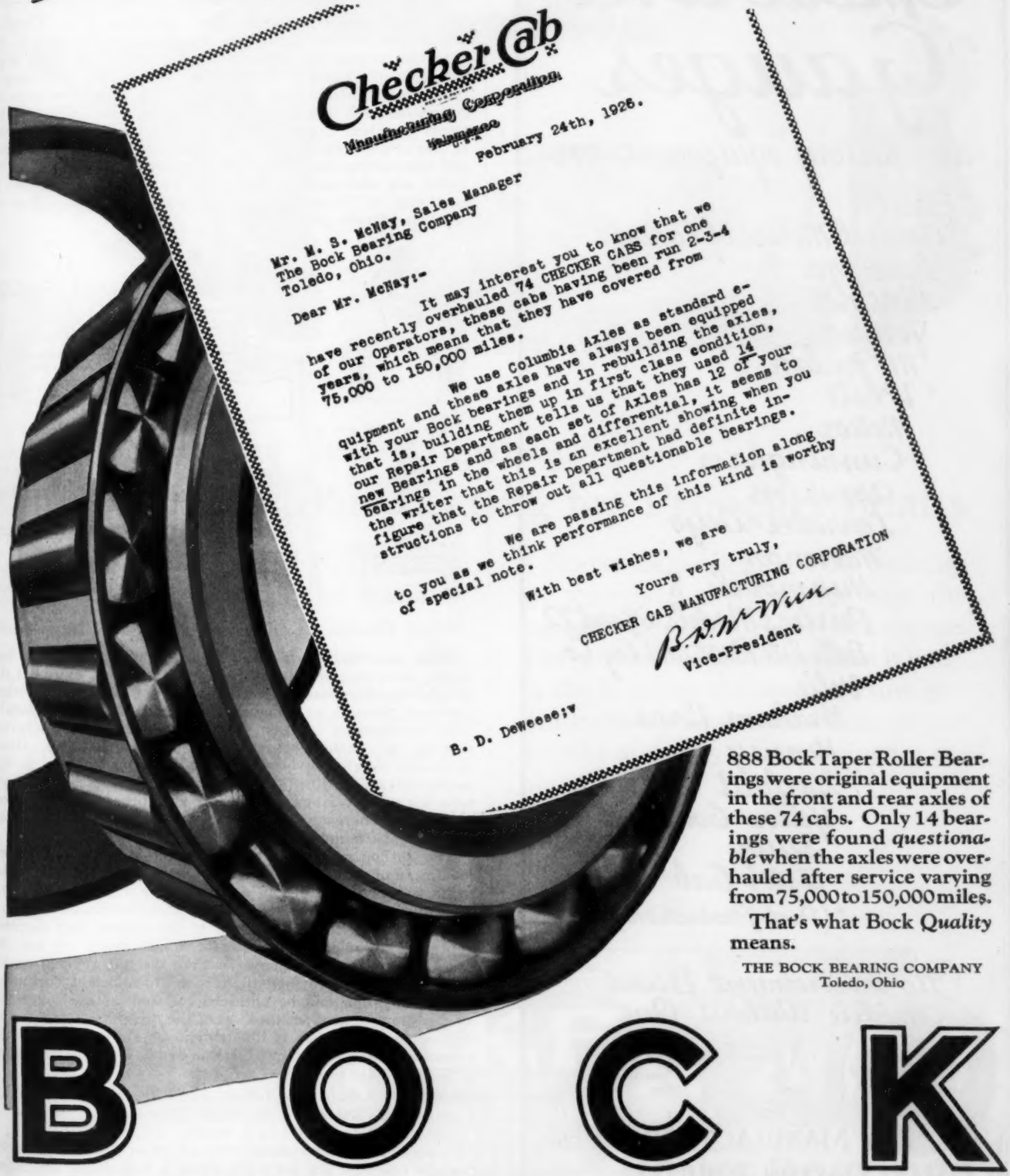
R. M. Warren has been made industrial engineer for H. R. Van Deventer, Inc., New York City. Until recently he was production manager of the Dubilier Condenser & Radio Corporation, also of that city.

John T. Watry has been elected president and general manager of the Meta-Mold Aluminum Co., Milwaukee. For the last 7 years he was associated with the Werra Aluminum Foundry Co., Waukesha, Wis.

John H. Weller has resigned as vice-president and factory manager of the Gray Motor Co., Detroit, to accept the position of general manager of the Acme Motor Truck Co., Cadillac, Mich.

Walter B. Wessells, who was formerly sub-foreman for the installation of equipment for the Western Electric Co., Chicago, has been made assistant engineer on system valuation for the Great Western Power Co., San Francisco.

Only 1½% Replacement after 75,000 to 150,000 miles


Checker Cab
Manufacturing Corporation
Chicago
February 24th, 1926.
Mr. M. S. McKay, Sales Manager
The Bock Bearing Company
Toledo, Ohio.
Dear Mr. McKay:-
It may interest you to know that we have recently overhauled 74 CHECKER CABS for one of our Operators, these cabs having been run 2-3-4 years, which means that they have covered from 75,000 to 150,000 miles.
We use Columbia Axles as standard equipment and these axles have always been equipped with your Bock bearings and in rebuilding the axles, that is, building them up in rebuilding the axles, our Repair Department tells us that they used 14 new Bearings and as each set of Axles has 12 of your bearings in the wheels and differential, it seems to the writer that this is an excellent showing when you figure that the Repair Department had definite instructions to throw out all questionable bearings.
We are passing this information along to you as we think performance of this kind is worthy of special note.
With best wishes, we are
Yours very truly,
CHECKER CAB MANUFACTURING CORPORATION
Vice-President
B. D. DeWeese;v

888 Bock Taper Roller Bearings were original equipment in the front and rear axles of these 74 cabs. Only 14 bearings were found *questionable* when the axles were overhauled after service varying from 75,000 to 150,000 miles.

That's what Bock *Quality* means.

THE BOCK BEARING COMPANY
Toledo, Ohio

BOCK

TAPER ROLLER BEARINGS

Grolan Gasoline Gauges

are factory equipment on

* Buick
* General Motors of Canada
Packard
Lincoln
Jordan
McFarlan
* White
Meteor
Cunningham
Apperson
Larrabee-Deyo
Marmon
Hupmobile 8
Peerless Models 69 and 72
Belle Isle Boat and Eng. Co.
Velie
Graham Bros.
Henney
Garford
Yellow Coach
Stutz
Astor Cab
*(Part Production)

"No Instrument Board Complete Without One"

Frank A Groves
PRESIDENT

The
GROLAN MANUFACTURING CO.
DAYTON, OHIO

Notes and Reviews

This column, which is prepared by the Research Department, gives brief items regarding technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The High Efficiency Oil Engine. By Alan E. L. Chorlton. Published in *The Automobile Engineer*, April, 1926, p. 127.

In this treatise the author first points out lines along which development should take place to increase the efficiency of the internal-combustion oil-engine. He then discusses the design-features that must be modified to make these developments possible. Increase in compression ratio is emphasized as one of the most important avenues to improved efficiency, and the outstanding experiments made with relation to this factor are summarized. Reduction of mechanical loss to the maximum of 15 per cent and higher engine-speeds are two other desiderata mentioned.

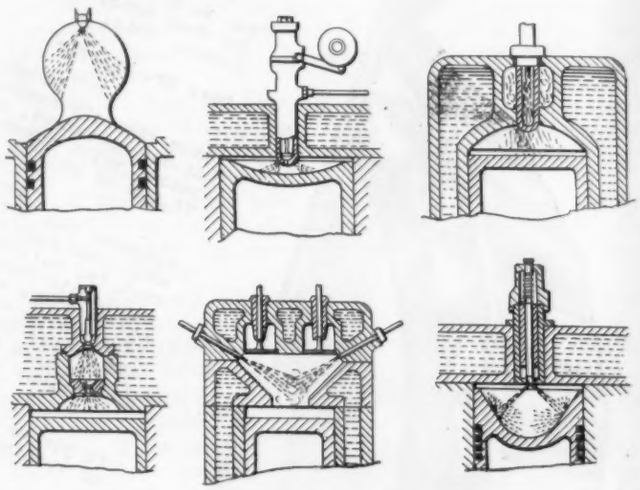


FIG. 1—TYPES OF COMBUSTION-CHAMBER USED IN OIL-ENGINES

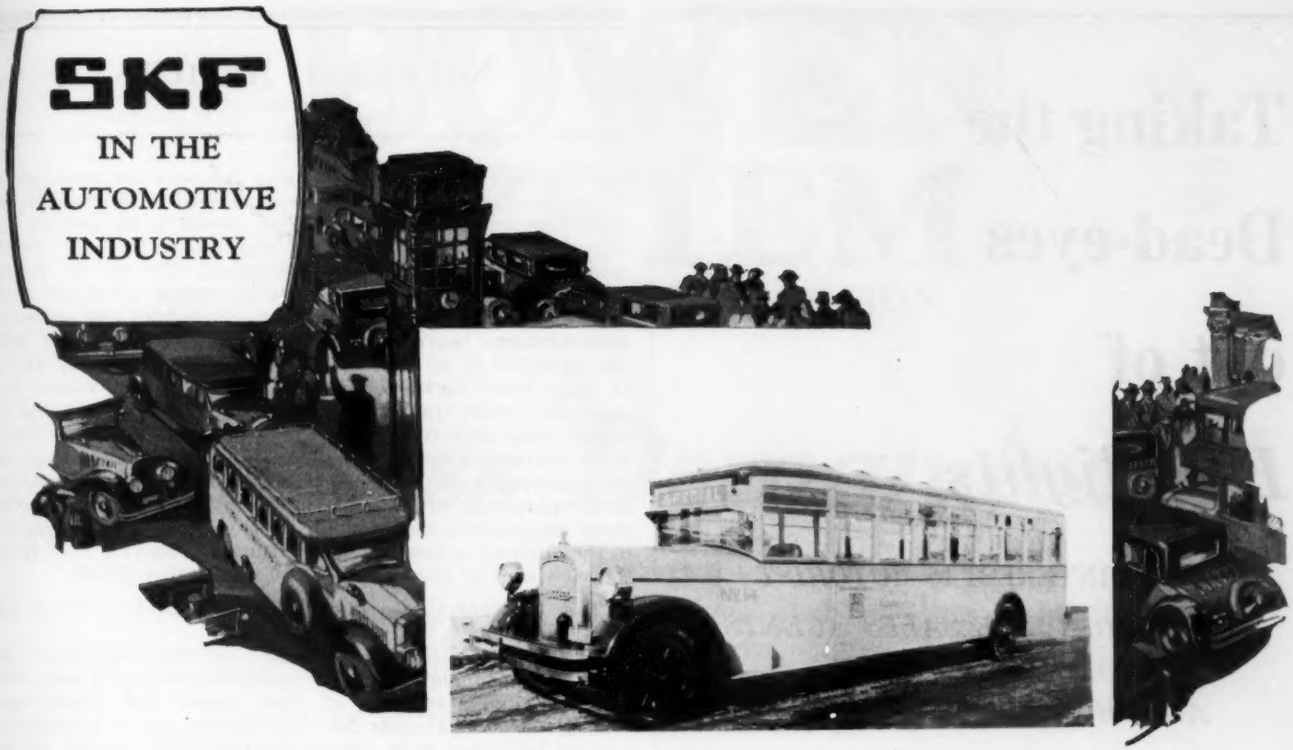
Most progress in meeting these requirements has been made, according to the author, by a type of engine using simple liquid-pressure-injection of the fuel direct, without air-blast, through an atomizer into the cylinder, and working with compression ignition. It operates on a cycle approximating the constant-volume. Changes in materials, dimensions and weights involved in adapting such engines to high pressures are outlined. High-pressure lubrication and pistons with fewer rings and lighter ring-pressures are recommended to increase mechanical efficiency and enable high speeds to be maintained.

The author next takes up the effect of speed on big-end loading, and the design-features necessary to secure complete utilization of heavy oils in quick-running engines. In Fig. 1 are illustrated several forms of combustion-chamber in use. In the globular form, according to the author, any desirable degree of turbulence can be created. However, its use presents certain disadvantages, so that the flat type is considered preferable, provided that, with it, sufficient turbulence and atomization can be obtained. Essential characteristics of fuel-pumps are outlined, and the principle of the type devised by the author is illustrated. A short description of a quick-running engine manufactured by William Beardmore & Co. concludes the paper.

Oil-Electric Locomotive Likely To Take Precedence in Demand for Gas-Oil. By Paul Truesdell. Published in *National Petroleum News*, March 31, 1926, p. 49.

Gas-oil from a specific gravity of 26 or 28 American Petroleum Institute deg. up, and having a flash-point not higher than 150 deg. fahr. is the fuel of the Diesel-electric engine as

(*Continued on p.* 26)



Skayef—The Self-Aligning Ball Bearing for Propeller Shafts

PROPELLER shaft bearings for busses are called upon to "stand up" under unusually hard going at times. There's no doubt about the necessity of having dependable bearings for this location if "on time" service is to be maintained and operating expenses kept at the lowest possible figure.

Skayef Self-Aligning Ball Bearings are especially designed to meet the requirements of propeller shaft service. The property of self-alignment is within the bearings themselves. Just give 'em fresh lubricant every three or four months and they'll keep going for the life of the bus!

SKF INDUSTRIES, INCORPORATED
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Taking the Dead-eyes out of *Headlights*

OF INTEREST to *MOTORISTS*
AUTOMOBILE SALES AGENTS
and
AUTOMOBILE MANUFACTURERS

STRANGE, isn't it, when there's one dull headlight on an automobile it's almost sure to be a dead-eye on the left—just where lack of light invites trouble when cars pass at night.

Sometimes the fault is in the bulb, or there may be a faulty contact. But often a light is dull or dead because a reflector has lost its sheen

That is bound to occur when reflectors are made of corrodible metal Rust kills their lustre.

Logically, the remedy is the installation of reflectors made of metal that does not rust. There is, in fact, official insistence upon that kind of metal.

In Massachusetts, the Registrar of Motor Vehicles specifies that reflectors "must be made of a non-corrosive material, preferably brass."

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RESEARCH ASSOCIATION
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NOTES AND REVIEWS
Continued

used in the rail-car. It forms also the most desirable stock for the majority of cracking processes used in the production of motor-car fuel. This grade of gas-oil is in demand by manufacturers of artificial gas and is the fuel for which domestic oil-burners are being designed. The advent of the oil-electric locomotive therefore raises several questions with regard to fuel supply. The author enumerates and presents considerations bearing on the following of them: (a) will the adoption of oil-electric locomotives be sufficiently rapid to make them big factors in the gas-oil market within the next few years; (b) if so, will the oil industry be able to supply them with fuel and at the same time satisfy the three other sources of demand for gas-oil; (c) will the savings by the railroads using oil-electric instead of steam locomotives be great enough to permit them to outbid, if necessary, the three competing consumers; and (d) does the use of gas-oil in the oil-electric locomotive constitute a "superior use" from the viewpoint of the Federal Oil Conservation Board.

Is This the £100 Car? Published in *The Motor*, March 23, 1926, p. 339.

M. Eugene Fejes, a Hungarian engineer, has attracted much attention abroad by his demonstration of a car constructed almost entirely of sheet metal and stampings. Among the claims made for this vehicle are a production cost of less than £100 (approximately $486), speed of 60 m.p.h. and fuel-consumption of 60 miles per gal. on a 4 to 1 top gear-ratio. The 1244-cc. (75.915-cu. in.) four-cylinder engine is said to develop a power output of 34 hp. The chassis weight is approximately 900 lb.; the wheelbase, 10 ft.; and the tread, 4 ft. The engine gearbox, rear axle and chassis frame are constructed of thin low-grade steel or iron stampings welded together. Construction methods used in the production of this car are described in some detail, with emphasis laid on the low labor-cost and the reduction in car-weight achieved by them.

Anticipations. By Henri Petit. Published in *La Vie Automobile*, April 10, 1926, p. 133.

In his attempt to visualize the motor-car of ten years hence, the author does not look forward to any radical change, but to development along lines already indicated and further applications of principles already known. In his opinion, the future is reserved almost entirely for the sedan type of body, with a large seating-capacity, and built in accordance with streamline principles. The balloon tire will be universally used, although its form may be slightly modified to effect a solution of the problems now involved in its use. Leaf springs of the present type will still persist, but suspension by independent wheels will be far more common than at present.

In 1935, the author predicts, the fuel used by heavy commercial-vehicles will only in rare instances be gasoline. Engines burning producer gas, Diesel engines and engines using heavy oil will propel motor trucks and motorcoaches. Gasoline, with heavier fractions than at present, will be the fuel of passenger cars. Almost all gasoline sold will contain a certain proportion of some anti-knock chemical.

Engines, to use these non-detonating fuels economically, will have higher compression-ratios. They will be so designed as to reach their maximum power at 5000 or 6000 r.p.m. Superchargers will find a place on some passenger cars, but they will not be used universally. Gas turbines will probably not find a commercial application in the automotive field within the next 10 years.

In conclusion, the author makes predictions concerning several details of construction; for instance, better methods of valve control; change-speed gears and rear axles approximately the same as at present; servo-brakes on 90 per cent of vehicles; and a limited use of six-wheel and creeper-track trucks.

(*Continued on p.* 28)

BOWEN SYSTEM
OF CHASSIS LUBRICATION

Progress Demanded It

It had to come. Progress demanded easier starting and the electric starter was perfected. Progress demanded surer braking. Four-wheel brakes solved that problem. Progress demanded easier riding. Balloon tires met that demand. Progress demanded a better method of chassis lubrication. The Bowen System meets this demand to the unqualified satisfaction of the most exacting.

The Bowen System makes the chassis as easy to lubricate as the motor. A single push on the lubricator button lubricates perfectly every chassis bearing—automatically and simultaneously. It eliminates the usual long, tiresome job with all its dirtiness and disagreeable features. It replaces, with positive lubrication, ineffective guess work of present hit and miss methods.

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BUS HEATING SYSTEM

NOTES AND REVIEWS

Continued

The Economics of Carbureting and Manifolding. By R. W. A. Brewer. Published by Crosby Lockwood & Son, London. 176 pp.; 63 illustrations.

Why, that little piece of pipe, I did not think that there was any specialization about that.

This, according to the author, was the reaction of an eminent British engineer to his remark that he was specializing on inlet-manifold design. The present book is an indication of how far astray the engineer was in his disparagement of the magnitude of the problem. The book extends in subject matter over all the various angles of the manifolding question; in time, from 1912 to the present; and in sources consulted, over the field of British and American research.

After outlining the duties of the inlet-manifold, the author discusses some factors affecting its performance, conditions influencing the flow of gas, the evaporation temperatures of liquid-fuel mixtures, and the results on manifolding of varying the size and shape of the fuel orifice. One chapter is devoted to crankcase-oil dilution and another to methods of saving fuel in existing engines. An account of the author's investigations in this field and a presentation of types of manifold now in use complete the book.

Much of the material presented in this book is drawn from previously published accounts of experiments carried out in Great Britain and in this Country. Many extracts have been made from Bureau of Standards publications and from THE JOURNAL. Frequent reference is made to the work of such well-known writers on carburetion as F. C. Mock and P. S. Tice. The treatise is therefore a guide to further research as well as a general summary of the subject of manifolding.

Closed Vessel Explosions of Mixtures of Air and Liquid Fuels—Petrol, Hexane and Benzene—over a Wide Range of Mixture-Strength, Initial Temperature and Initial Pressure. By R. W. Fenning. Aeronautical Research Committee Reports and Memoranda No. 979. Published by His Majesty's Stationery Office, London. 28 pp.; 16 illustrations.

This is the second report issued on an investigation to determine the influence of compression temperature and pressure on the production of detonation in internal-combustion engines. In this paper are reported experiments to determine the effect of varying (*a*) the air-fuel ratio from 19 to 1 to 9 to 1 for gasoline and from 17 to 1 to 9 to 1 for hexane and benzene; (*b*) the initial temperature from 100 to 230 deg. cent. (212 to 446 deg. fahr.) and the initial pressure from 38 to 128 lb. per sq. in., absolute, for a 13 to 1 air-gasoline mixture and a 14 to 1 air-hexane mixture; (*c*) the initial temperature from 100 to 200 deg. cent. (212 to 392 deg. fahr.) for a 9.2 to 1.0 air-hexane mixture, and (*d*) the initial temperature from 100 to 300 deg. cent. (212 to 572 deg. fahr.) and the initial pressure from 37 to 146 lb. per sq. in., absolute, for a 12 to 1 and a 9.2 to 1.0 air-benzene mixture. The effect of additions of exhaust gas and water vapor to air-hexane and air-benzene mixtures was also tested.

In addition to describing the tests and setting down the general conclusions arrived at, the report tabulates in great detail the results of the experiments.

Anti-Knock Motor Fuels Derived from Cracking Shale Oils. By Jacque C. Morrell and Gustav Egloff. Published in *National Petroleum News*, April 28, 1926, p. 81.

The authors state as accepted conclusions that at some future date shale will be utilized as a source of gasoline for automotive engines and that the cracking of shale oil produces a motor-fuel high in anti-knock qualities. He makes the following estimate of the probable supply of gasoline obtainable from the oil-shale deposits now known to exist in various parts of the world: from those in the United States, 54,000,000,000 bbl.; Tasmania, 165,000,000 bbl.; New South Wales, 150,000,000 bbl.; France, 12,500,000 bbl.; and Scot-

(*Continued on p.* 30)

CG PARABAR

Protected— from the "other fellow"

He's a terrible driver—that "other fellow". You've met him yourself—possibly with disastrous results. He's the man that stops suddenly ahead of you without a signal, or dashes madly across a through street intent on getting somewhere in a hurry.

If you are fully prepared for such emergencies you do the best you can to avoid a crash—then place your confidence in your CG Bumpers. Hundreds of drivers today would tell you that they owe their lives to this equipment—the last word in safety engineering.

To install less sturdy and dependable equipment is to work upon yourself a real hardship.

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(47)

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After exhaustive tests, some of them covering a period of 3 years, these Engineers have adopted as standard equipment—

The UNITED AIR CLEANER

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What more conclusive proof can we offer of "United" superiority?

United Air Cleaners shut out 99% of all road dust
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United Air Cleaners require no adjusting—no attention whatever

United Air Cleaners are guaranteed for the life of the motor

Made in sizes to fit all motor cars, buses, tractors, trucks, and industrial motors

We will be glad to co-operate with you and furnish for test the correct type of United Air Cleaner for your motors.

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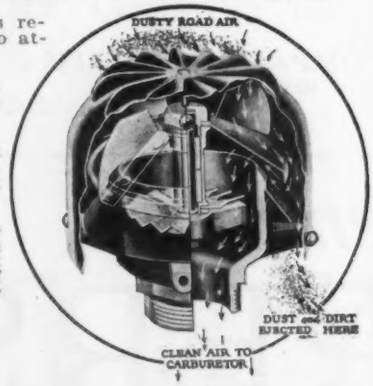

United Manufacturing & Distributing Co.
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NOTES AND REVIEWS

Continued

land, 1,000,000 bbl. The distillation ranges found in gasolines obtained from American, Australian and French shale oils are given. Chemical analyses are said to show that these gasolines have a high aromatic hydrocarbon equivalent, and results of such chemical analyses are tabulated together with the corresponding Ricardo compression ratio. The treatment of cracked distillates from shale oils is described. Finally, several conclusions are drawn as to the supply of gasoline from oil shale; among them that the supply from this source in the United States would be sufficient to fill motor-fuel requirements for 50 years, based on present consumption figures.

Dopes and Detonation. By H. L. Callendar, R. O. King and C. J. Sims. Published in *Engineering*, (London) April 9, p. 475; April 16, p. 509; April 23, p. 542; and April 30, 1926, p. 575.

For the information contained in this article, the authors are indebted to an investigation made at the Air Ministry Laboratory of the Imperial College of Science and Technology. The object of this investigation was to discover some rational explanation of the mode of action of such dopes as are already known, as a guide to the discovery of other effective anti-detonating substances that are free from objectionable characteristics and readily available in sufficient quantities at any time.

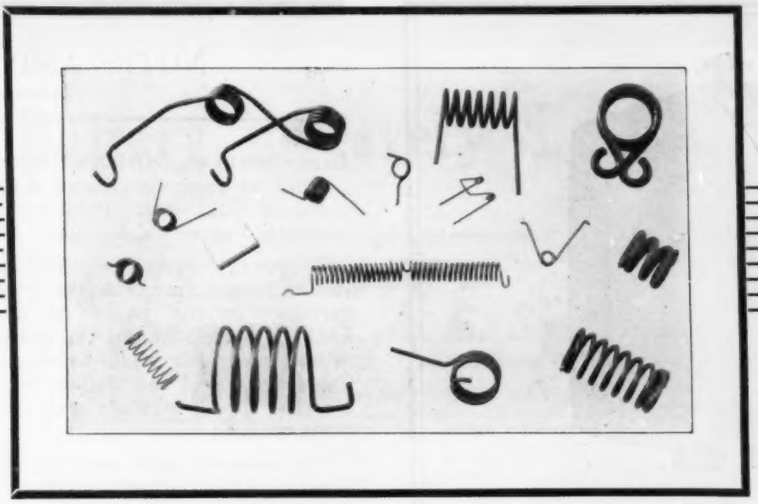
Four main divisions make up the article. The first part gives a general account of the theoretical aspects of the subject, with a brief summary of previous experimental work, leading up to a possible explanation of the action of anti-detonating substances based on the known properties of nuclei of various kinds in promoting condensation and chemical action. Part 2, entitled Nuclear Theory of Self-Ignition, summarizes the main points of a working hypothesis that has been devised to account for some of the peculiar features of detonation, with special reference to the effect of dopes. The third part, entitled Experiments in Sealed Tubes, describes experiments of a physical nature on the properties of various selected substances, with a view to illustrating and confirming the suggested explanation. Some of the substances tested were tetra-ethyl lead, nickel carbonyl, aniline, methyl aniline, ethyl aniline, m-toluidine, and phenyl hydrazine. Experiments on the same substances in a variable-compression engine constitute the subject matter of the fourth part. The engine tests were designed to illustrate the correspondence of the physical properties of the substances with their effectiveness in retarding the occurrence of detonation.

Flow of Heat in Pistons. By H. A. Huebotter and G. A. Young. Purdue Engineering Experiment Station Bulletin No. 25. Published by Purdue University, LaFayette, Ind. 119 pp.; 67 illustrations.

In this bulletin five general rules for obtaining satisfactory distribution of metal in plain pistons are developed. Detailed suggestions are also made regarding ribs, piston rings, ring-land radial clearance, and methods of expansion control.

These principles of piston design are developed by mathematical analysis of heat-flow from the hot gas through the piston and into the cylinder-wall. The theory of thermal-flow is applied to the several components of the piston, and equations are derived for the solution of general design problems. The analytical study is supplemented by laboratory tests on a large variety of standard and special pistons in the piston testing plant. So that the reader may obtain easily a clear understanding of the results, an effort has been made to present the general discussion independently of the mathematics used in the investigation. However, the mathematical calculations have been included for the convenience of those who wish to apply the methods to their own problems.

(*Continued on p.* 32)



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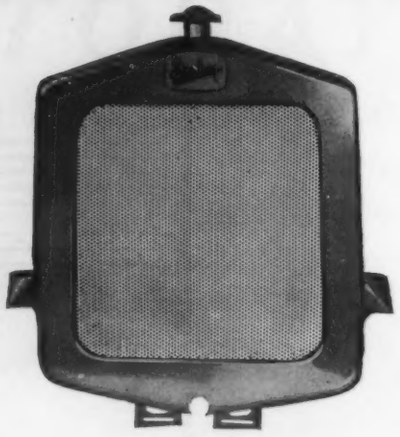

4 Direct Advantages of Perfex Cooling

Below are listed four direct advantages to manufacturers using Perfex Bronze-Core Radiators.

Engineering: **15 years' experience provides much practical, field-tested data in cooling. Saves designing time and cuts down experimental work for you.**

Production: **The jobs we send out conform strictly to specifications. Built with accurate tool and production equipment, they help keep production flowing smoothly. They fit perfectly—and on the first trial. A modern plant safeguards delivery schedules.**

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Operating: **A Perfex Radiator does all that a scientifically correct radiator *can* do to keep your motor at its best for the owner, and he *knows* it.**

These points are supported by the fact that over 100 well known manufacturers use Perfex Bronze-Core Radiators. Our engineering staff of experienced cooling specialists and radiator builders is at your services for estimates or complete plans and specifications.

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It's worth remembering that of all exhibitors showing gas-powered machines at the 1926 Chicago Road Show, 90% use Perfex Radiators.

PERFEX
THE PERFECT RADIATOR

NOTES AND REVIEWS
Continued

Experiments on Laminated Springs. By H. S. Rowell. Reprint of paper presented before the Institution of Automobile Engineers. Published by the Institution of Automobile Engineers, London. 40 pp.; 48 illustrations.

Excessive volume and discordance in results, according to the author, characterize the present literature on laminated springs. In his paper he describes some experimental methods for examining the premises on which spring calculations rest. His work, he says, has led to an exact and reliable system of calculation, to be presented later. In this treatise spring stresses and spring friction are the topics dealt with.

The methods here used for the determination of stresses depend on the assumption that the principal stresses in the leaves of laminated springs are due to bending of the leaves. Using the accepted theory of bending, the stresses are deduced by measuring the changes of curvature in the leaves. The principles and formulas involved in the methods advocated are set forth, the apparatus used in applying them are described and several concrete examples are cited.

In introducing his second topic, the author points out that knowledge of friction in general is not sufficiently advanced to permit precise deductions concerning spring friction. Further, even the most careful calculations acquire an approximate character because of the variations in the finished spring due to manufacturing conditions. He then shows how from simple static experiments a measure of the kinetic friction may be deduced, from which the general quantity of damping is obtained. Diagrams are developed which show the varying characteristics of the interleaving combined with the effects of buckling of the leaves. Finally, the friction in laminated springs is said to be almost entirely solid friction.

The Economical Use of Reclaimed Rubber as a Substitute for New Rubber. By J. M. Bierer and C. C. Davis. Published in *Industrial and Engineering Chemistry*, April, 1926, p. 348.

In this article the authors develop a method for determining under what circumstances and how reclaimed rubber may be substituted for the new material with economy to manufacturers and without impairing the quality of the rubber compound. Since reclaimed rubber is inferior in quality to new rubber, it cannot replace equal weights of the latter in a compound. However, partial replacement of new rubber by twice the weight of alkali tire reclaimed rubber, with proper alteration of the other ingredients, does not change many useful properties of the compound. The higher the grade of the compound, the smaller the replacement practicable.

The authors take issue with the methods used in the tests to determine the resistance to wear of tire treads containing reclaimed rubber, described in Bureau of Standards Technologic Paper 294. They find that in tire treads the resistance to abrasion may not be impaired when as high as 10 per cent of new rubber is replaced by tire reclaimed rubber. A small increase in carbon black and a decrease in zinc oxide, when such substitution is made, produce better wearing qualities and do not influence materially heat conductivity.

To utilize reclaimed rubber economically, the manufacturer must know the relation between the cost of the new rubber and of the greater quantity of reclaimed rubber that must enter into the compound if a substitution is to be made. By altering the relative proportions of new and reclaimed rubber the manufacturer can maintain the quality of his rubber products uniform in the most economical manner as the price of rubber changes. Much concrete information is given on the various aspects of the subject covered.

(*Continued on p.* 34)

A USL Battery for every S. A. E. Standard

MARCH 1926 N31

A USL Battery for every S. A. E. Standard

(See Pages B23, This Handbook)

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S.A.E. Battery Number	U.S.L. Type	U.S.L. Capacities	
		20 Min. Amperes	20 Hr. Amp. Hrs.
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2	3-CVX-6X	115	104
3	3-CVX-7X	134	121
4	3-HVX-8X	170	153
5	3-SOWJ-7Z	147	133
6	6-SOFJ-3X	63	57
7	6-CVX-5X	96	87

MOTOR TRUCK RECOMMENDATIONS

S.A.E. Battery Number	U.S.L. Type	U.S.L. Capacities	
		20 Min. Amperes	20 Hr. Amp. Hrs.
11	3-SBXJ-3X	68	69
12	3-SBXJ-4X	90	92
13	3-SOXJ-6X	126	114
14	3-SOXJ-7X	147	133
15	3-SOXJ-8X	168	152

MOTOR COACH RECOMMENDATIONS

S.A.E. Battery Number	U.S.L. Type	U.S.L. Capacities	
		20 Min. Amperes	8 Hr. Amp. Hrs.
21	3-SOXJ-8X	168	118
22	3-SBFJ-7X	158	129
23	3-SOXJ-12X	252	178
24	6-SOXJ-6X	126	89
25	6-SOXJ-6Z	126	89
26	6-SOXJ-7X	147	104

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Reprinted from March 1926 S.A.E. Handbook

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NOTES AND REVIEWS

Continued

Second Progress Report on the Relation of Road Surfaces to Automobile Tire Wear. By H. J. Dana, H. V. Carpenter, H. E. Phelps, H. H. Langdon, W. A. Pearl, and Harry Nash. Engineering Bulletin No. 17. Published by State College of Washington, Pullman, Wash. 19 pp.; 3 illustrations.

The tests described in this report constitute the second series in the investigation, the first having been completed in 1924. They were road-tests in which measurements were made of the weight losses in tires after running over various types of road, at various speeds and air temperatures. The results of tests are tabulated, as well as some figures obtained from a preliminary investigation into the relative gasoline consumption on hilly and level highways.

The conclusion drawn is that, considering the average of all sizes of pneumatic tires for passenger cars, the amount of tread rubber worn off in the life of the tire will approximate 2½ lb. The difference in tire cost to the motorist between travel on crushed rock macadam and on pavement is $14.40 per 1000 miles per car. On the basis of tire wear alone, it would require a traffic of 34,800 cars per year to justify the building of the better road. The excess gasoline cost in traveling over hilly as compared with level highways is said to range between $1.85 and $2.77 per 1000 miles.

Sizes and Types of American Tires. Published in *The India Rubber World*, May 1, 1926, p. 74.

Here are listed the many different sizes and types of tire in use on automotive vehicles, with a notation opposite each of the number of vehicle types on which it is standard equipment. The information is given in 10 tables; 5 devoted to the various sizes of motor truck and 1 each to motorcoaches, passenger cars, taxicabs, electric trucks, and motorcycles. These compilations are said to show strikingly the many tire sizes now in use, and the urgent need for some system of tire standardization.

A Photometric Method for Measuring The Hiding Power of Paints. By H. D. Bruce. Bureau of Standards Technologic Paper No. 306. Published by the Bureau of Standards, City of Washington. 9 pp.; 8 illustrations.

This paper presents the results of an investigation carried out at the Bureau of Standards to develop a method for measuring from dry films the hiding power of paints. A photometric method was evolved in which the contrast is measured between the two shades of a black and white plate showing through a thin overlying coating of paint. The degree of this contrast is a function of the film thickness and the hiding power of the paint. The relationship between the film thickness and its effected contrast is worked out, whereby, with the formulas and tables presented, the hiding power in square feet per gallon can be readily calculated.

Assemblee Generale du 17 Mars 1926. Published in *A. C. F.*, April, 1926, p. 1.

In this article is incorporated the annual report of the Automobile Club of France. The membership of the National Federation of Automobile Clubs of France is said to consist of 36 clubs and 68,000 individuals. Bureaus for the examination of applicants for drivers' licenses have been set-up, with the Federation's assistance, in 73 departments, and these issued 267,487 licenses in 1925. The Minister of War has just authorized the Federation to organize courses of instruction to prepare young men for service in the automotive divisions of the army.

Following the recital of these and many other general national activities of the Club, the report summarizes the accomplishments of the various committees. Separate committees function for each of the following spheres of activity; racing, pleasure motoring, judicial and legislative matters, the publication of the Bulletin, engineering, and club administration.

(*Continued on p.* 36)

Mechanics Universal Joints

A Factor In Rickenbacker's Popularity

In the short span of a few years Rickenbacker cars have attained nation-wide recognition. Men and women who appreciate smart cars know Rickenbacker.

Its distinct charm and grace, coupled with its mechanical excellence, have won the enthusiasm of thousands upon thousands of car owners.

Notable engineering advancements have made the Rickenbacker a wonderful car to handle. Lightning getaway, quick acceleration, cushioned deceleration, and all-around flexibility feature the Rickenbacker's performance.

Mechanics Oil Lubricated Universal Joints are part of Rickenbacker's quality construction. No more need be said about the excellence of **Mechanics** Universal Joints. If Eddie Rickenbacker chooses them, they **have** to be good. If they were otherwise, they wouldn't be in Rickenbacker cars.

Because of a special design which allows side thrust to be taken on the ends of the trunnions, **Mechanics** Universal Joints do not develop noise.

They run an entire season with one filling of oil.

Rickenbacker
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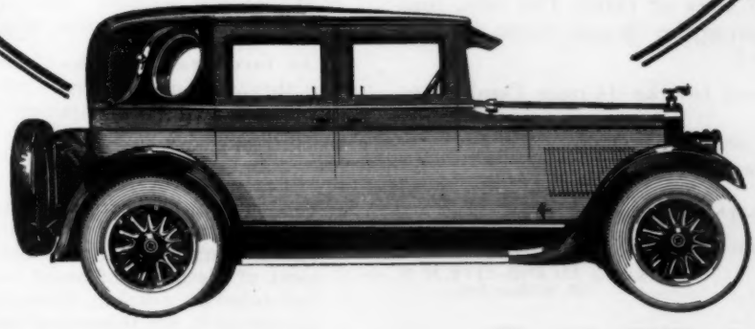

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NOTES AND REVIEWS

Continued

Report of a Study of Highway Traffic and the Highway System of Cook County, Illinois. Published by Bureau of Public Roads, City of Washington, and Cook County Highway Department, Chicago. 96 pp.; 30 illustrations.

This report contains a great many interesting and detailed statistics concerning highway traffic in Cook County. They were collected during the summer and fall of 1924 under the cooperative research agreement between the Bureau of Public Roads and the Cook County Highway Department. Using as a basis the essential facts set forth, the report outlines a plan for the development of the highway system in the Chicago regional area to serve present and future traffic. The conclusions reached are based upon the present density, type, loading, and distribution of traffic units; present population and population trends; predicted future traffic; and an analysis of other factors affecting highway development.

Increasing the Efficiency of Passenger Transportation in City Streets. By John A. Miller, Jr. Published in *Proceedings of American Society of Civil Engineers,* May, 1926, p. 827.

In the past, says the author, plans for the relief of traffic congestion have called for more roadway area to be used exactly as is the existing area. Permanent relief is not obtained from such increased area, in his opinion, and to provide it, enormous expenditure is necessary. An alternative remedy is more intensive use of present streets. The elimination of automobile parking is one expedient suggested under this heading. Figures are quoted which are intended to show that this would increase the effective width of streets from 30 to 200 per cent, would not seriously inconvenience the majority of people, would reduce the running time of street cars by several minutes, and would aid rather than injure retail business. The second expedient proposed is the substitution of motorcoaches for private cars that carry, on the average, less than two persons per vehicle, and for taxicabs, the average loading of which is less than one passenger.

Operating Costs for All Types. Published in *The Commercial Motor,* March 23, 1926, p. 188.

Complete itemized figures are here given of the operating costs and fixed charges for commercial vehicles. The minimum charges per mile or per week that will make a profit for the operator is also indicated. Separate tabulations are made for each of the following type of vehicle: motor vehicles equipped with cushion or pneumatic tires, motor vehicles equipped with solid tires, steam vehicles, London pneumatic-tired motorcoaches, London solid-tired motorcoaches, pneumatic-tired motorcoaches operating in the provinces, solid-tired motorcoaches operating in the provinces, and electric vehicles. The figures given are averages based on the actual experience of owners of each type of vehicle.

An Investigation of the Coefficient of Discharge of Liquids through Small Round Orifices. By W. F. Joachim. National Advisory Committee for Aeronautics Report No. 224. Published by National Advisory Committee for Aeronautics, City of Washington. 10 pp.; 8 illustrations.

The work covered by this report was undertaken in connection with a general investigation of fuel-injection engine-principles as applied to engines for aircraft propulsion, the specific purpose being to obtain information on the coefficient of discharge of small round orifices suitable for use as fuel-injection nozzles. These were determined as the ratio of the actual to the theoretical rate of flow where the theoretical flow was obtained by the usual simple formula for the discharge of liquids through orifices.

Values for the coefficient were determined for the more important conditions of engine service such as discharge under pressures up to 8000 lb. per sq. in., at temperatures

(*Continued on p.* 38)

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NOTES AND REVIEWS

Continued

between 80 and 180 deg. fahr. and into air compressed to pressures up to 1000 lb. per sq. in. The results show that the coefficient ranges between 0.62 and 0.88 for the different test-conditions between 1000 and 8000 lb. per sq. in. hydraulic pressure. At lower pressures the coefficient increases materially.

Following are the conclusions drawn: (a) within the range of these tests and for hydraulic pressures above 1000 lb. per sq. in. the coefficient does not change materially with pressure or temperature; (b) it depends considerably upon the liquid; (c) decreases with increase in orifice size, and (d) increases in the case of discharge into compressed air until the compressed-air pressure equals approximately 0.3 of the hydraulic pressure, beyond which pressure-ratio it remains practically constant.

Characteristics of a Boat-Type Seaplane during Take-Off. By J. W. Crowley, Jr. and K. M. Ronan. National Advisory Committee for Aeronautics Report No. 226. Published by the National Advisory Committee for Aeronautics, City of Washington. 11 pp.; 15 illustrations.

This report, on the planing and get-away characteristics of the F-5-L seaplane, gives the results of the second of a series of take-off tests on three different seaplanes conducted by the National Advisory Committee for Aeronautics. The single-float seaplane was the first tested, and the twin-float seaplane is to be the third.

The characteristics of the boat type were found to be similar to the single float, the main difference being the increased sluggishness and the relatively larger planing resistance of the larger seaplane. At a water speed of 15 m.p.h. the seaplane trims aft to about 12 deg. and remains in this angular position while plowing. At a 22.5 m.p.h. the planing stage is started and the planing angle is immediately lowered to about 10 deg. As the velocity increases the longitudinal control becomes more effective but overcontrol will produce instability. At the get-away the range of angle of attack is from 19 to 11 deg. with velocities from the stalling speed through about 25 per cent of the speed range.

Investigation of Turbulence in Wind Tunnels by a Study of the Flow about Cylinders. By H. L. Dryden and R. H. Heald. National Advisory Committee for Aeronautics Report No. 231. Published by the National Advisory Committee for Aeronautics, City of Washington. 17 pp.; 19 illustrations.

With the assistance and cooperation of the National Advisory Committee for Aeronautics, the Bureau of Standards has been engaged for the last year in an investigation of turbulence in wind tunnels, especially insofar as turbulence affects the results of measurements in different wind-tunnels.

Two methods of making such studies are described in this report together with the results of the use in the 54-in. wind-tunnel of the Bureau of Standards. The first method consists in measuring the drag of circular cylinders and the second in measuring the static pressure at some fixed point. Both methods show that the flow is not entirely free from irregularities.

The Siddeley Jaguar's 17,000 Miles. Published in *Flight*, April 8, 1926, p. 205.

The report of the Aircraft Inspection Department on the condition of the Armstrong-Siddeley Jaguar engine after the completion of the flight from London to Cape Town and return is embodied and commented on in this article. The greatest amount of wear discovered in any one part is given as 0.002 in., and in many vital parts no wear at all was detected. These results are said to be all the more remarkable in view of the 4400-lb. load carried and the severe conditions encountered and to constitute a triumph for the air-cooled engine.

(*Continued on p.* 40)

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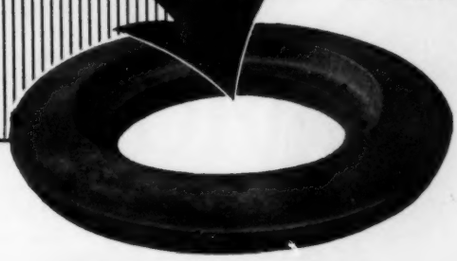

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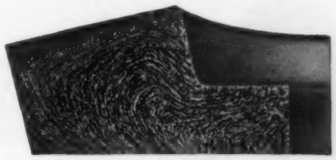

Cross section of turned forging, upset from 4 square, showing average section of entire forging. Note the structure.

The Old Method
Double Conversion

Cross section of forging made from flat steel, the old method. Note how flow lines run parallel to face angle, producing an irregular structure.

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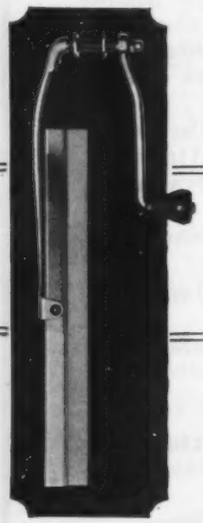

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A high grade rubber wiper that clearly cleans the windshield, without leaving in its path disturbing blurs. The metal parts are heavily nickel plated, with a high polish, built to last. A floating joint between spring arm and wiper holder. Write for samples, quotations.

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NOTES AND REVIEWS

Continued

Performance of Air-Speed Tubes Exposed to Rain Drops and Freezing Rain. By J. E. Eshbaugh. Air Service Information Circular No. 549. Published by the Chief of the Air Service, City of Washington. 18 pp.; 17 illustrations.

The tests, which simulated actual flight through rain drops and freezing rain were conducted in a 6-in. suction wind-tunnel constructed especially for the investigation. Tests were made on the following tubes: five of the Pitot-static type, one of the Venturi-Pitot, one of the Venturi-static, one of the double-throat Venturi, and eight experimental types.

Standard Engine Test of Curtiss D-12 High and Low-Compression Engines. By J. W. Carl and W. W. Bishop, Jr. Air Service Information Circular No. 550. Published by the Chief of the Air Service, City of Washington. 33 pp.; 43 illustrations.

The results of this test are summarized in the following table:

Compression-Ratio	6.0 to 1.0	5.3 to 1.0
Normal Power—Full Throttle at 2,200 R.P.M., b.hp.	443.000	431.000
Fuel Consumption at Normal Power, lb. per hp-hr	0.510	0.540
Oil Consumption at Normal Power, lb. per hp-hr.	0.010	0.010
Normal Brake Mean Effective Pressure, lb. per sq. in.	137.500	133.800
Total Weight, Dry, lb.	694.000	693.000
Weight, Dry, per Normal Brake Horsepower, lb.	1.566	1.607

The mean effective pressures of the Curtiss D-12 engine are said to be well above those of concurrent service engines and its weight-horsepower ratio correspondingly lower. The fuel consumption, however, is rather high. The fact that the engine has satisfactorily completed several 50-hr. endurance tests at considerably above the normal design speed indicates excellence in detail design. Mention is made of the general use of intricate aluminum castings and rather difficult cylinder-block assembly operations.

A Simple Theoretical Method of Analyzing and Predicting Airplane Performance. By Ivan H. Driggs. Air Service Information Circular No. 553. Published by the Chief of the Air Service, City of Washington. 8 pp.; 4 illustrations.

The formulas given in this report are intended, first, to show the relation of certain fundamental variables to absolute ceiling and to rate of climb and, second, to allow an estimate to be made for these quantities with the minimum of calculation. The calculations given are said to represent actual conditions only insofar as the mathematical expressions used closely approximate the actual curves of available and required horsepower for which they are substituted. The results obtained are said to be probably as accurate as the flight-test figures with which they are compared. The formulas are therefore thought to be suitable for general use.

N.A.C.A. Fight-Path-Angle and Air-Speed Recorder. By Donald G. Coleman. National Advisory Committee for Aeronautics Technical Note No. 233. Published by National Advisory Committee for Aeronautics, City of Washington. 11 pp.; 13 illustrations.

This new trailing bomb-type instrument consists essentially of an inclinometer, air-speed meter, constant-speed motor, and a film-drum case. The inclinometer carries an oil-damped pendulum which records optically the flight-path angle upon a rotating motor-driven film drum. The air-speed meter consists of a taut metal diaphragm of high natural frequency which is acted upon by the pressure difference of a Prandtl type Pitot-static tube. The inclinometer record and air-speed record are made optically on the same sensitive film. Two records taken by this instrument are shown.

(*Concluded on p.* 42)

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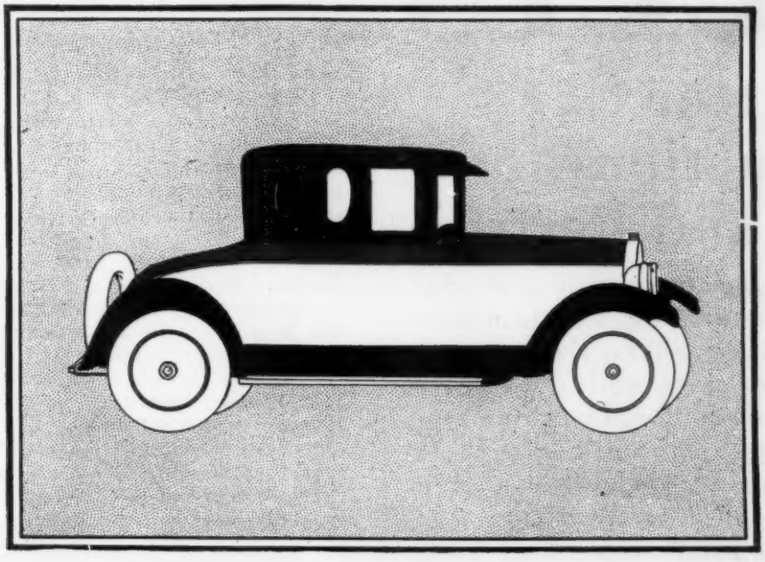

Captain Towle said, **in a talk on "Color and its relation to the Automobile," before the recent Annual Meeting of the Society of Automotive Engineers in Detroit, "In the case of the Coupe, however . . . The element of design containing the windows is so comparatively short in ratio to the over-all length of the car from front to rear that it is inclined to look somewhat box-like unless linked closely in color with the top of the shroud and the rear deck. It would seem to me, then, that the upper body of a Coupe should best be in one or two darker colors extending to the lower band moulding, and that the balance of the body should be lighter . . . "**

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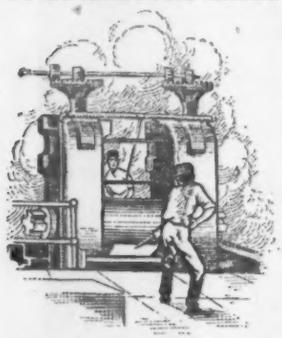

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NOTES AND REVIEWS

Concluded

An Investigation of the Characteristics of Steel Diaphragms for Automatic Fuel-Injection Valves. By W. F. Joachim. National Advisory Committee for Aeronautics Technical Note No. 234. Published by National Advisory Committee for Aeronautics, City of Washington. 22 pp.; 15 illustrations.

The work here recorded determined the load-deflection, load-deformation and hysteresis characteristics for single diaphragms having thicknesses of from 0.002 to 0.012 in. and for similar diaphragms tested in multiple having total thicknesses of from 0.012 to 0.180 in. The elastic-limit loads and deflections and rupture points of single diaphragms were also determined. Some work was done on diaphragms having central orifies to determine the effect of orifice diameter upon the load-deflection characteristics.

Steel diaphragms used in multiple are found to have capacities and characteristics that make them suitable for use in automatic fuel-injection valves.

Some Problems in Airplane Structural Design. By H. B. Howard. Published in *The Journal of the Royal Aeronautical Society*, April, 1926, p. 238.

The author of this paper on modern methods of airplane strength calculations is a member of the airworthiness department of the Royal Aircraft Establishment. He checks the airworthiness of all new civil and many new military aircraft.

In his treatise he presents, not a general summary of standard methods, but a detailed treatment of certain points thought to be of particular interest. Under standard methods he selects for discussion the formula for calculating thrust and inertia forces, and the limiting nose-dive and inverted-flight cases. To bring out the advantage of the use of more exact knowledge, he then deals with the load distribution over tapered wings. As an example of the analytical complexity of aircraft structural problems, the staggered spar is discussed. The final topic is the present status in Great Britain and the United States as to the use of accelerometer records in estimating external loads.

The Lighting of the London-Continental Airway. By C. H. Bidddlecombe. Published in *Aviation*, April 12, 1926, p. 550.

This article is characterized as an authoritative discourse on the night flying system employed on the Imperial Airways route from London to the Continent. Among the lighting equipment described are the following: two different types of aerial lighthouse, boundary lights used at landing-fields, three different types of illuminated wind-indicator, and a floodlight system.

Convertible Monoplane-Biplane Wings. By Randolph F. Hall. Published in *Aviation*, April 26, 1926, p. 632.

The author states that the line of wing development followed by him has proved interesting and encouraging. In this work an efficient and relatively deep section monoplane wing of high speed and climb characteristics is convertible into a biplane to obtain an increased lift for slow-speed performance. In addition to the convertible feature, slots communicating with the passageway between the wings are said to give promise of further improving performance. Results of a test on the convertible wing are given and a comparison between its characteristics and those of several other well-known airfoils is made. Criticisms of the wings are listed and answered, and suggestions made for its further development.

The Albatros L 72A. Published in *Flight*, April 15, 1926, p. 228.

This is said to be the first successful commercial airplane incorporating the slotted-wing device. It is to be used for the rapid distribution of newspapers, and a special arrangement is provided to allow parcels of newspapers to be shot overboard. A complete description of the airplane is given.

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Only One Bolt to Turn
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Stronger and Better Looking
Costs No More to Build

The most radical wheel and rim improvement in fifteen years—

A
Convex Inclined Surfaces enter Concave Inclined Surfaces (C) on the felloe.

B
Lock Lug on rim.

A
Convex Inclined Surfaces enter Concave Inclined Surfaces (C) on the felloe.

C
Concave Inclined Surfaces accommodate the opposite Convex Inclined Surfaces (A) on the rim.

C
Concave Inclined Surfaces accommodate the opposite Convex Inclined Surfaces (A) on the rim.

To Mount

Hook rim at valve stem. Swing rim downwards and wedges will enter inclined grooves, producing initial wedging action. A few turns of the bolt will then accomplish final locking.

To Remove

A few reverse turns of the bolt bring the wedging member back to neutral and rim can then be instantly removed.

The Kaplan Wheel and Rim is a new and noteworthy development in rim and wheel design, which cannot fail to appeal to motorists and car manufacturers.

A Kaplan rim can be removed and another put in place easily within one minute of jacking up. No longer need there be any wearisome road delays. Kaplan simplicity reduces tire changing to one simple, quick operation. A few turns of *One Bolt* removes the Kaplan rim or grips it firmly and rigidly in position with uniform pressure around the felloe.

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D
Inclined Wedging Members enter into grooved Inclined Surfaces (E) on the felloe.
A
Convex Inclined Surfaces enter Concave Inclined Surfaces (C) on the felloe.
J
Fixed bolt to move both Threaded Nut (H) and Wedging Member (G) to final locked position and back to neutral.
B
Lock Lug on rim.
A
Convex Inclined Surfaces enter Concave Inclined Surfaces (C) on the felloe.
D
Inclined Wedging Members enter into Grooved Inclined Surfaces (E) on the felloe.
E
Grooved Inclined Surfaces accommodate Inclined Wedging Members (D) on rim.
G
Wedging Member operates on Lock Lug (B) accomplishing final locking.
H
Threaded Nut that moves forward Wedging Member (G) to locked position and back to neutral.
F
Bracket with inclined guides raising Wedging Member (G) to locking position.
E
Grooved Inclined Surfaces accommodate Inclined Wedging Members (D) on rim.

One bolt turns the trick

With the Kaplan system one bolt replaces four or more. A few turns of this bolt drives forward a wedging member causing the rim to tighten firmly around the felloe. Yet there is no strain on the bolt. And the bolt itself is permanently attached to the felloe and cannot be lost or misplaced. A mounted tire can be changed in less than one minute.

Think of the convenience Kaplan wheels offer to the motorist. Think what a strong talking-point this time-saving device will be in the sale of a car. Think of the many sales advantages of this revolutionary new system of rim removal and replacement.

Kaplan wheels have proved their strength and endurance. They have been run thousands of miles on different makes of cars, demonstrating conclusively that they stand up under all road conditions.

Years of study and development lie behind Kaplan design. And Kaplan wheels are a convenience that the motorist has long awaited. There is added sales and profit for the manufacturers who will fill this long-felt need.

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WIRE WHEEL, Kaplan Equipped

The Kaplan System Fits All Types of Wheels and Rims

The Kaplan Wheel and Rim appeals to the most discriminating. Several unsightly bolts and lugs are eliminated. A neat bead on rim helps the appearance and gives added beauty to already superior strength. A glance at the illustration will show how much better-looking is this simple and more convenient system.

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Model 53, like all Whites, has been built to stand up and to give reliable service at low cost over hundreds of thousands of miles. The chassis throughout is designed and built especially to meet the requirements of the small bus field.
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DEPENDABLE DELIVERIES

Unaffiliated with any other concern or group of concerns, using or making ball bearings, the Fafnir Bearing Company enjoys a corporate and financial independence which is unaffected by the prosperity or adversity of any other company. Or of any industry—for Fafnir Ball Bearings are widely used in all industries.

Combined with Fafnir's large production capacity, this corporate independence, financial strength and wide distribution of sales offer the automotive manufacturer a reliable source of ball bearing supply,—a source that assures dependable deliveries now and in the future.

The Fafnir Bearing Company, New Britain, Conn., Newark, Chicago, Cleveland, Detroit.

Better finish in less time!

NITRO-VALSPAR

The Valentine Lacquer Finish

Seeing is Believing!

THERE are still a few people who just can't believe that anyone has developed a nitrocellulose Primer and Surfacer that really work.

To such people we extend a hearty invitation to come and see Nitro-Valspar in action, for, as we said before

Seeing is Believing!

Valentine and Company

Manufacturers of

Nitro-Valspar Valentine's Varnishes Valspar-Enamels

New York *Chicago* *Boston* *Detroit*

W. P. Fuller & Company, Pacific Coast

Versare Equipped with Waukesha "Ricardo Head" Six Cylinder Engine.

America's First Gas Propelled Street Car

This is not a fire engine but a ninety-six-passenger, 31,000 pound bus. The engine that so successfully handles this bus is making records in pumping on all fire engines to which it has been applied -- because of their special features such as the "Ricardo Head"--"Girder" type crankcase and "Fresh Oil" lubricating system.

These engines have been specified not only on new equipment but for replacement purposes by the Milwaukee Fire Department. Write for Four and Six Cylinder Bulletins, describing these engines.

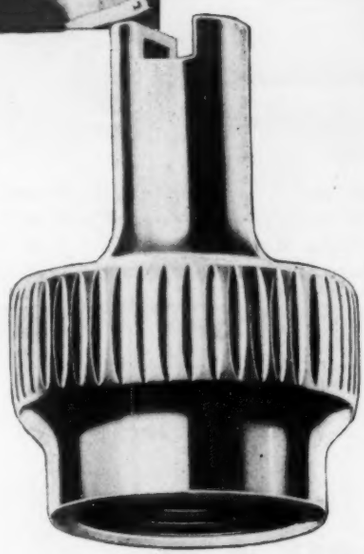
AUTOMOTIVE EQUIPMENT DIVISION

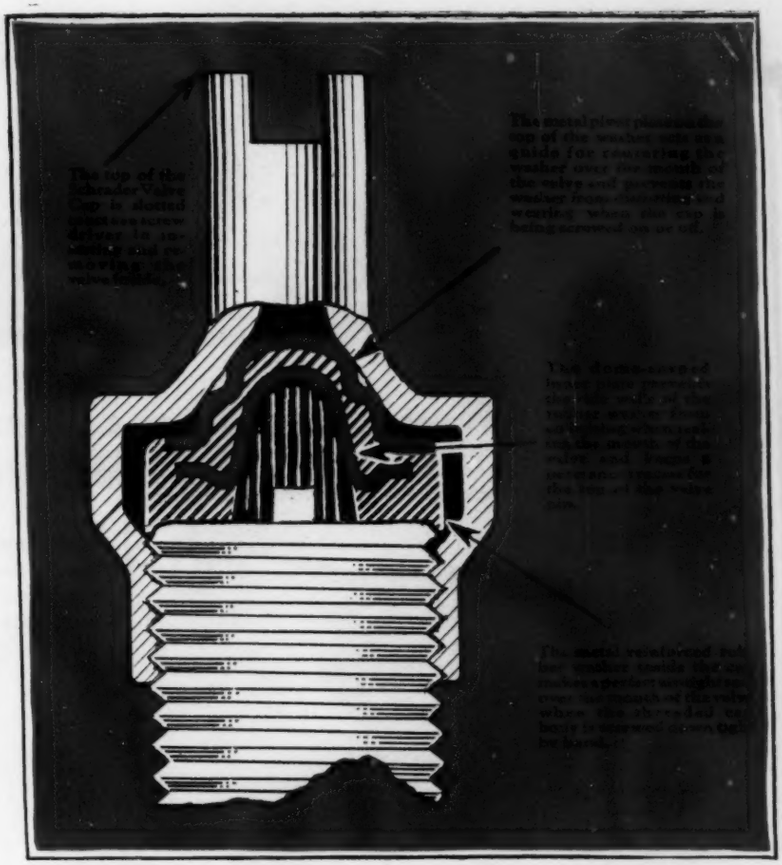
WAUKESHA MOTOR COMPANY

Waukesha Wisconsin

Eastern Sales Office Aeolian Building, 33 W. 42nd Street New York City

You can blow smoke through it, yet a Schrader No. 880 Valve Cap, screwed down tight by hand on the valve stem, makes a positively air-tight seal.





Guaranteed to seal air at the mouth of the valve

AIR cannot escape at the mouth of the tire valve, if a Schrader No. 880 Valve Cap is screwed down tight by hand over the mouth of the valve stem.

This cap is guaranteed absolutely air-tight at any pressure up to 250 pounds.

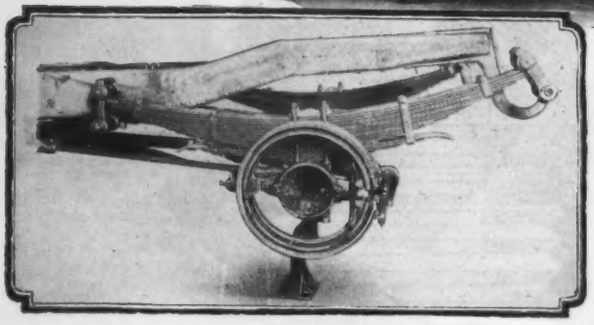
The reinforced dome-shaped rubber washer inside the cap forms an absolutely air-tight seal at the mouth of the valve stem. Use only Schrader No. 880 Valve Caps with Schrader Tire Valves.

A. SCHRADER'S SON, Inc., BROOKLYN, Chicago, Toronto, London

Schrader

Makers of Pneumatic Valves Since 1844

TIRE VALVES TIRE GAUGES



This motor coach, equipped with Vanadium Steel chassis springs, was designed and built in the shops of the Motor Transit Co. It is now in service between Los Angeles and San Diego.

Why Motor Transit Co. Uses Vanadium Steel Springs

"Vanadium Steel has been used in all of our bus springs for some time," states the Motor Transit Co., Los Angeles, California.

"We have found that this spring steel has longer life, greater dynamic strength and its resistance to fatigue is far above ordinary carbon steel springs.

"Springs of Vanadium Steel hold their height longer than carbon springs. We find these springs are also more uniform in stress per inch of movement.

"We have tried several makes of steel but we find the Vanadium alloy, which we use at present, gives us superior service and longer life than any of the cheaper steels, making these springs the cheapest in the long run."

Would you improve the springs or other steel parts of your products? Our Metallurgists will gladly assist you, and place at your disposal valuable data gained in many automotive steel researches. When you avail yourself of this service, you are not obligated in any way.

VANADIUM CORPORATION OF AMERICA

NEW YORK
120 Broadway

DETROIT
Book Bldg.

VANADIUM STEELS

for strength, toughness and durability

DISTINCTIVE

Vanity Cases, Smoking Sets Ash Receivers

Flush and Hang-on Types

Exclusive designs in Walnut, Mahogany and Ebony, with Pearl and Silver Inlay. Patented metal construction, durable, practical and attractive.

Metal Door Trim Panels, Instrument Boards and Mouldings to match, in beautiful Walnut and Mahogany effects.

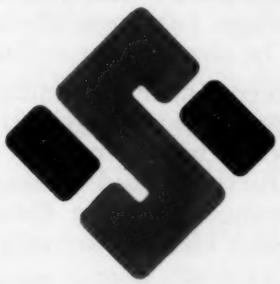
See these handsome trimmings in America's finest closed cars.

Grand Rapids Metalcraft Corporation
(*Formerly* DOERR MFG. CO.)
Grand Rapids Michigan

Detroit Office: J. E. ECKENRODE, *Vice-President*,
3167 General Motors Building.
Telephone: Empire 7411.

SEIBERLING

In no fleet of ten or more Commercial Vehicles have **SEIBERLING ALL-TREADS** failed to average 20000 miles or better



THE SEIBERLING RUBBER COMPANY, AKRON, OHIO

OVER four-fifths of all makes of motor vehicles in America are equipped with Timken Tapered Roller Bearings. But considering trucks and buses separately, the Timken showing is even stronger—more than nine-tenths of all makes of commercial vehicles are Timken-equipped!

Where purely financial considerations rule, Timken Bearings rule overwhelmingly. The only answer can be sheer brute endurance and scientific design.

Timken Taper inherently provides more load area. Timken-made electric furnace steel puts the finest material where motion would otherwise be most destructive. And Timken positive roll alignment is assurance that the theoretical advantages of the Timken idea are actually realized on the job.

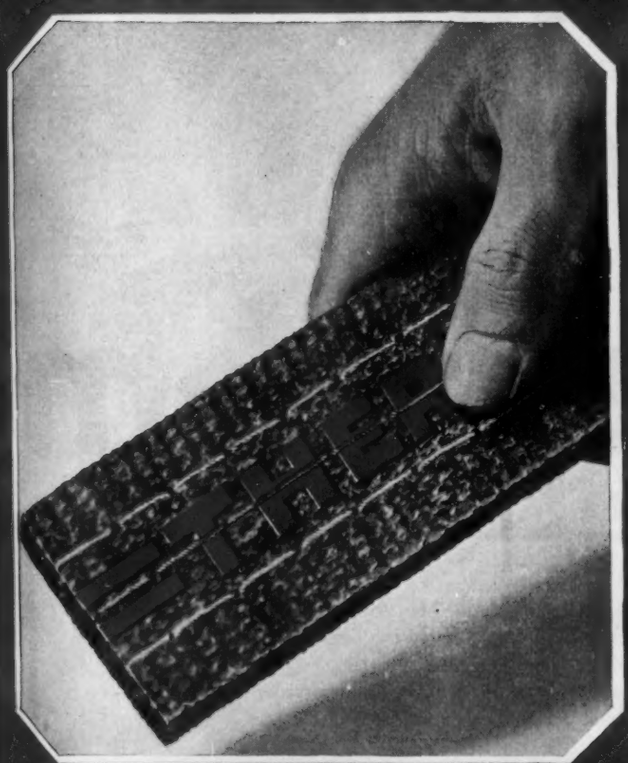
Not only is specified capacity obtained in less space by using Timken Bearings, but they also carry thrust without added parts. Mountings can therefore be more simple and lighter, with improved accessibility.

Also eliminating excess friction, Timken Bearings save power and lubricant while guarding against depreciation. You can have all these economies in trucks which meet your needs, since there are so many Timken-equipped makes.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO

TIMKEN
Tapered
ROLLER BEARINGS

Here's the Thing for Four-Wheel Brakes



Thermoid

Hydraulic Compressed

Brake Lining

The Asbestos Brake Lining

"For short stops and long service"

AN indifferent lining can give the motorist enough trouble in two-wheel brakes. With four-wheel brakes that trouble is multiplied by two.

The new close-set twill weave now used in Thermoid makes it the boss lining for four-wheel jobs. The extra density of this weave gives Thermoid a "pre-shrunk" quality that—

Insures a uniform co-efficient of friction—minimizes adjustments—and makes Thermoid practically immune to swelling in wet weather.

Have you tested Thermoid lately?

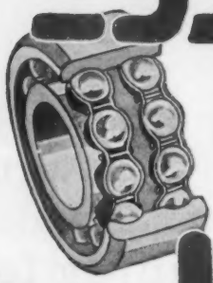
THERMOID RUBBER COMPANY

Factories and Main Offices

TRENTON, N. J.

Makers of Thermoid and Rexoid Transmission Lining, Thermoid-Hardy Universal Joints, Thermoid Radiator Hose and Mechanical Rubber Goods

Mo-lyb-den-um



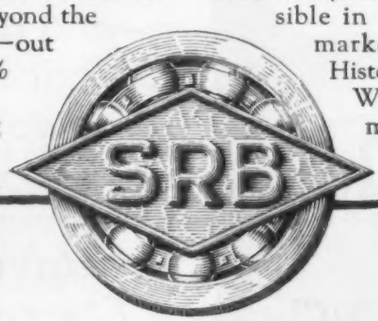
means

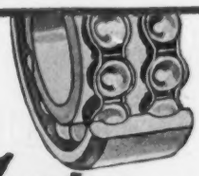
More-Life-in-'em

CAN you visualize the savings?—25% longer bearing life! Can you place a value on the greater strength—the greater load carrying capacity—the greater durability—of an SRB Ball Bearing with—25% longer life? Here is ball bearing performance pushed beyond the usual expectation of engineers—out of ordinary calculation—25% longer life!

When SRB Bearings whirling around on Forged Molybdenum Steel Balls year after year, consistently proved in actual tests and service that they had greater strength, greater resistance to wear, greater load carrying capacity—at least 25% longer life than had ever been possible in any anti-friction bearing, SRB marked another epoch in Bearing History.

Write us for further details and more complete information.





SRB Bearings are serviced by the Standard Sales and Service Company, Plainville, Conn., with direct factory branches at New York, Cleveland, Cincinnati, Detroit, Chicago, Kansas City and more than 300 distributors throughout the United States

-at least 25% more!

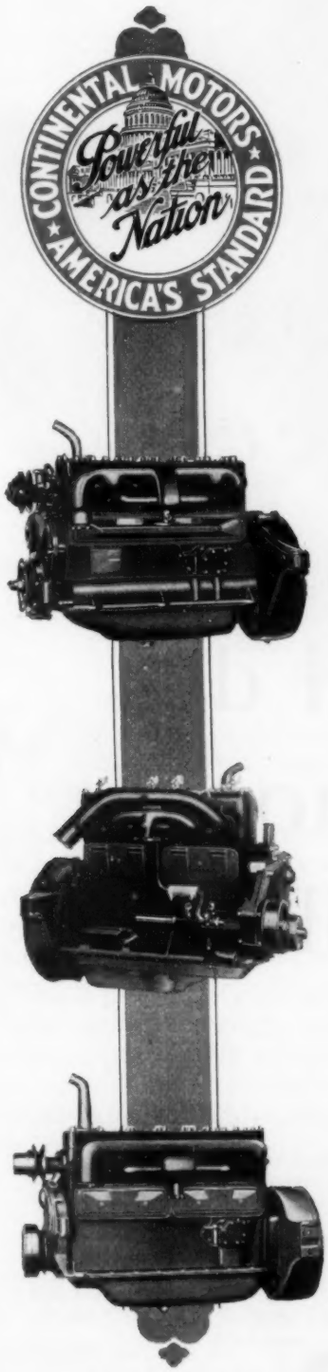
-in actual performance

STANDARD STEEL AND BEARINGS INCORPORATED

Plainville

USE SRB BALL BEARINGS-*First!*
—they'll last

Connecticut



The Standard of Perfection

True precision accuracy and scientific care are combined to attain the standard of perfection in Continental Motor building.

Upon the motor rests almost the entire structure of successful and trouble-proof motor car operation.

Accurate tooling and testing of crank shafts make for perfect balance; large bearings aid in smoothness of operation, scientifically correct lubrication and case hardened gears operate quietly over a long period of time.

It is this superiority of workmanship and design, plus long life of materials, which give to Continental Motors their lasting value and years of service.

CONTINENTAL MOTORS CORPORATION

Offices: Detroit, Mich., U. S. A. *Factories:* Detroit and Muskegon

The Largest Exclusive Motor Manufacturer in the World

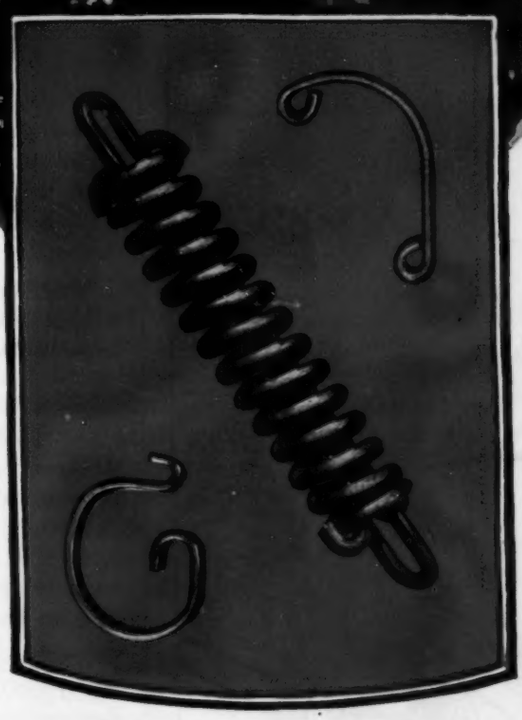
Continental Motors

Is the body *All-Steel* . . . or is it merely wood-and-steel? That question, more and more, will determine the choice of automobile buyers

EDWARD G. BUDD MFG. CO.

Philadelphia and Detroit

Originators of the All-Steel Automobile Body



HOW often have you marveled at the giant skyscrapers that tower above our modern city streets!

And yet, has the progress along this line of engineering been any more amazing than the development of the special machinery for scientifically heat treating Cleveland Coiled and Flat Springs?

With a precision and accuracy not so long ago once thought impossible this electric brain daily turns out thousands of springs for America's greatest and most particular industries.

Also manufacturers of Steel Shop Barrels, Tote Boxes, Steel Shelving, Steel Stools, Steel Waste Cans and Specialties.

THE CLEVELAND WIRE SPRING CO.
Main Office and Factory, Cleveland, Ohio
Branches:
CHICAGO, Machinery Hall DETROIT, Garfield Bldg.

CLEVELAND
COILED AND FLAT SPRINGS

On Sunday afternoon in 1905

WITH the family perched high on the rear seat—with father and perhaps yourself cutting the wind in front, the motor-car in 1905 stuttered and staggered its way across an incredulous countryside. The Sunday afternoon drive in those days was the high spot of the week's entertainment—it was one of the thrills of that distant decade.

Many cars and many accessories have come and gone in the ensuing years, but one name has survived them all, and still represents the highest attainment in its field. That name is Prest-O-Lite.

Today Prest-O-Lite Storage Batteries light and start millions of cars in all parts of the world—and furnish the power which brings the finest radio programs to the humblest homes.

The Prest-O-Lite sign marks "The Oldest Service to Motorists" and a capable dealer.

THE PREST-O-LITE CO., INC.
INDIANAPOLIS, IND.
New York San Francisco
In Canada: Prest-O-Lite Company of Canada, Ltd.
Toronto, Ontario

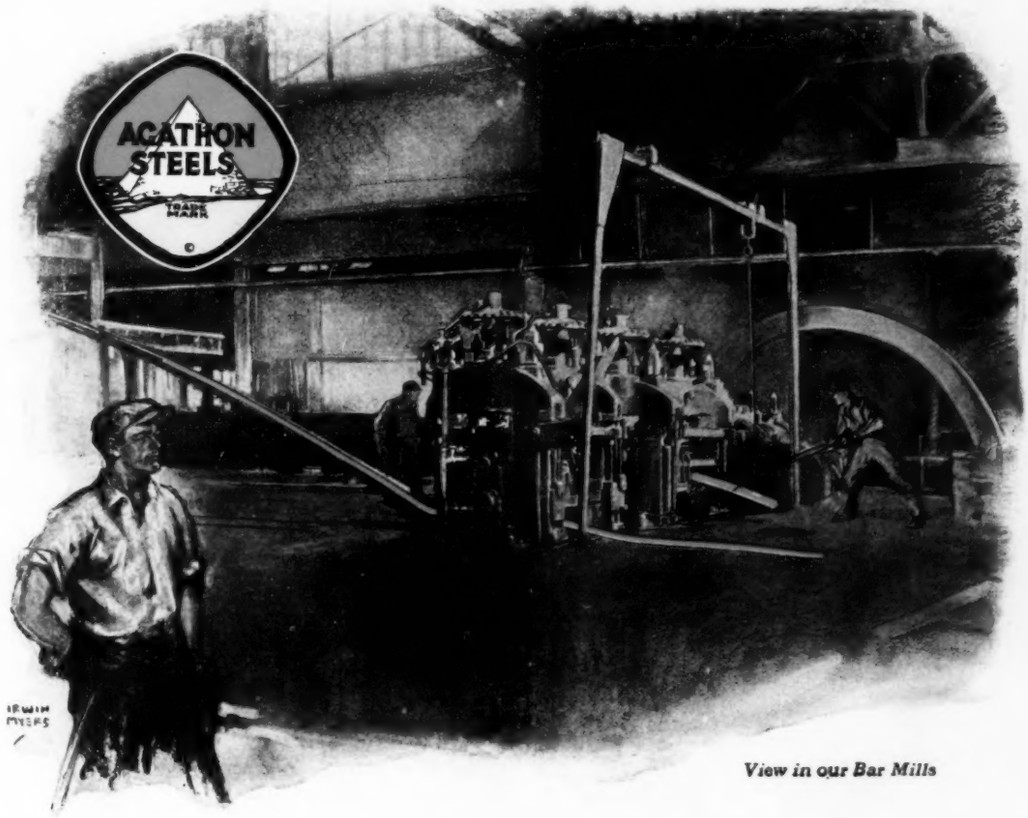
* * *

It is no longer necessary to take a chance on a battery of unknown make. You can buy Prest-O-Lite Automobile Batteries from $15.50 up—and Radio Batteries from $4.75 up.

The oldest service to motorists

Prest-O-Lite

STORAGE BATTERIES FOR MOTOR-CARS AND RADIO



View in our Bar Mills

Super-steels Born of Necessity

WITH the coming of the motor car came many new and varied steel requirements. Some parts had to withstand unprecedented wear, others unusual shocks, still others greater stresses and strains than were ever before demanded of products in quantity production. Many of those steel problems were solved by our staff of metallurgists and practical steel men. As a consequence of this contribution to the industry we have become the largest alloy steel makers in the world. And every pound of steel made under our trade name—"Agathon"—truly fulfills its translated meaning—*utmost in quality*. Our handbook will be sent on request.

We have daily production in all kinds of Agathon Alloy Steels such as—

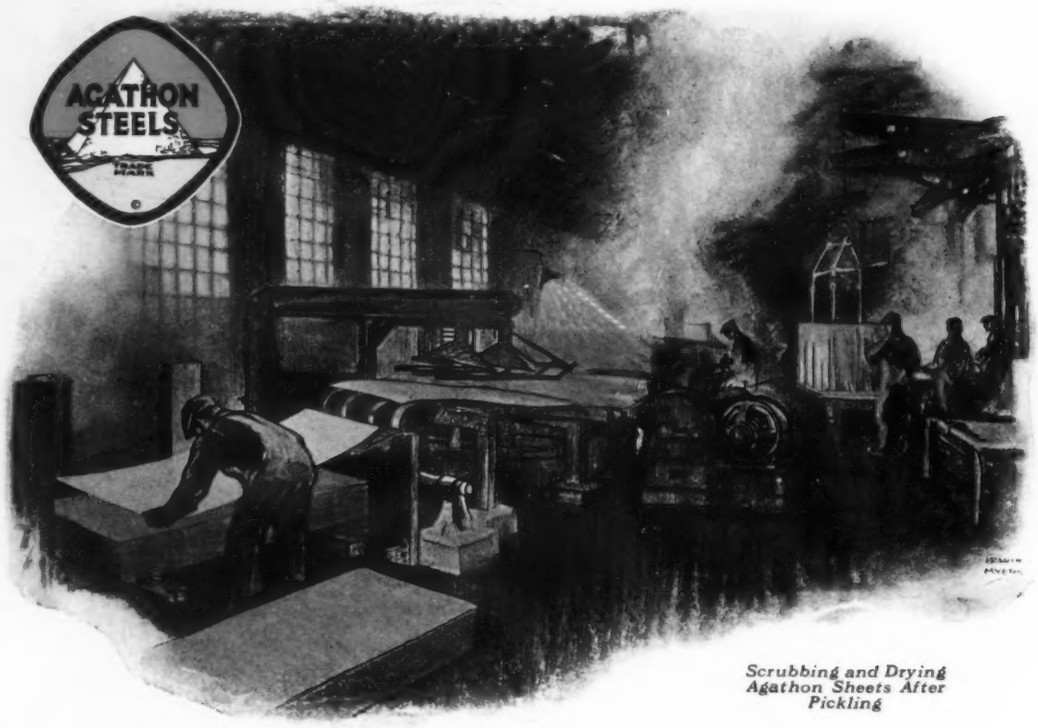
Nickel, Chrome-Nickel, UMA, Molybdenum, Chrome-Molybdenum, Nickel - Molybdenum, Vanadium, Chrome-Vanadium, Chromium, etc.

Deliveries in Blooms, Billets, Slabs, Hot Rolled, Heat Treated, and Cold Drawn Bars, Hot Rolled Strips, etc.

THE CENTRAL STEEL COMPANY, Massillon, Ohio

Swetland Bldg., Cleveland — Book Bldg., Detroit — Peoples Gas Bldg., Chicago
Aeolian Bldg., New York — University Block, Syracuse — Widener Bldg., Philadelphia
303 W. P. Story Bldg., Los Angeles, California

AGATHON ALLOY STEELS



Scrubbing and Drying Agathon Sheets After Pickling

Sheets That Are Esteemed Where Needs Are Most Exacting

MADE of special open hearth pickled sheet bars—rolled and finished by the most modern methods and equipment—pickled, scrubbed and dried by special machinery of our own design—it's no wonder that Agathon sheets are held in such high esteem by users whose requirements are most exacting. Agathon sheets have a smooth, clean, highly polished surface and a uniform texture that lends itself perfectly to deep drawing. Tell us about your sheet requirements.

Use Agathon Sheet Steel for

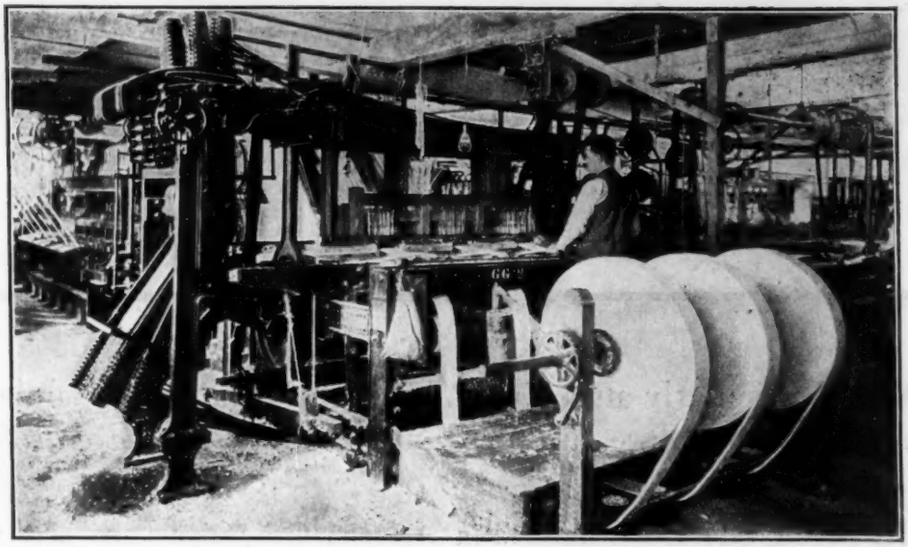
Automobile Bodies
Cowls
Hoods
Crown Fenders
Metal Furniture
Metal Doors and Window Casings
Railroad Car Interiors, Etc.

THE CENTRAL STEEL COMPANY, Massillon, Ohio

Swetland Bldg., Cleveland — Book Bldg., Detroit — Peoples Gas Bldg., Chicago
Aeolian Bldg., New York — University Block, Syracuse — Widener Bldg., Philadelphia
303 W. P. Story Bldg., Los Angeles, California

AGATHON SHEET STEEL

solidly woven



Gigantic Rusco Brake Lining Loom

RUSCO Brake Lining is a solid-woven lining, *solidly woven* on special looms designed and built in our own shops. These looms are among the heaviest used by any manufacturer of brake lining. Being solid-woven and solidly woven are two separate advantages which are two of the most important reasons why Rusco Brake Lining wears down evenly and slowly and brakes efficiently until worn through. Samples, out of stock, gladly supplied engineers for testing. Send coupon below. The Russell Mfg. Co., Dept. B 16, Middletown, Conn. Branches: Atlanta, Chicago, Detroit, New York.

RUSCO BRAKE LINING

Commands the Car

Prove Rusco's dependability, durability and efficiency without obligation and at no cost—Mail this coupon

The Russell Mfg. Co., Dept. B16, Middletown, Conn.

Gentlemen: Send me a free sample of Rusco Brake Lining so that I may try it out on my own car, which is a (give make and model) .....I agree only to write you after a fair test expressing my opinion of Rusco. Except for that, there is positively no obligation on my part.

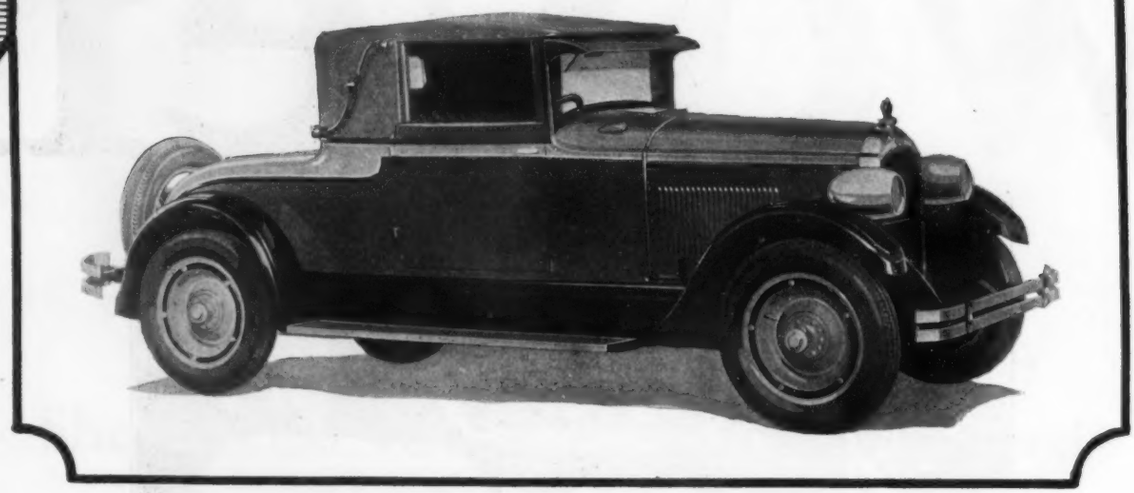
Name .....

Street .....

City..... *State*.....

Name of Motor Company.....

PAIGE



TWO particularly attractive Paige models, the Brougham and Cabriolet shown here, are now going out *lacquered exclusively in Egyptian.*

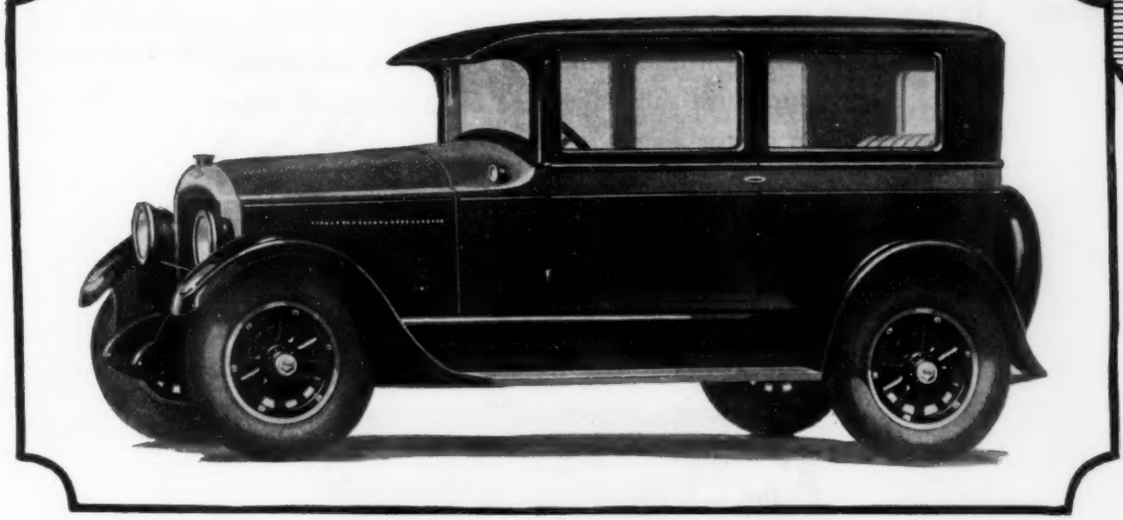
THE BROUGHAM is finished in Arizona Gray above the belt and Pueblo Gray below, with a Black top, and the Cabriolet is finished in Ocean Blue with a panel of Sea Fog Gray. These combinations are pleasing and very serviceable.

THE BUYERS of these Egyptian-lacquered Paige models are going to make two pleasing discoveries about the finish of their new cars:

SUPERIOR LACQUER

EGYPTIAN AUTOMOBILE FINISH

EGYPTIAN
AUTOMOBILE FINISH



FIRST, that it is a finish of exceptionally deep lustre. It is probably not quite right to say that the buyer will "discover" this. For the beauty of the deep-lustre Egyptian finish will be one of the first things to attract him to the car.

SECONDLY—and this will be a genuinely pleasant discovery—the buyer of these Paige models is going to find that his car has a deep-lustre finish THAT WILL WEAR LIKE IRON.

AND what two characteristics of finish could bring greater satisfaction to the new car owner and reputation to the car itself? BEAUTY—and beauty THAT IS PERMANENT.

The Egyptian Lacquer Mfg. Company
90 West St., New York City

Chicago **Los Angeles** **San Francisco**

FOR FIFTY YEARS

EGYPTIAN

Ultimately—

Car owners will demand Oil Filtrators whose performance and durability are on a par with other proven motor accessories.

These Filtrator features are in demand:

1. **Durability**—no replacement of units or parts.
2. **Cleanable** filtering elements.
3. **Leak-proof** at all oil pressures.
4. **100% Bearing Protection**—from motor abrasives.
5. **Efficient Performance**—throughout temperature and pressure range.

We maintain a staff of lubricating and filtrator experts for the purpose of assisting you with your lubricating problems. Write us for copy of **"Filter Facts,"** number three, which gives very thorough and complete information on the filtering problems of the internal combustion engine.

THE H—W—FILTRATOR

(HALL-WINSLOW PATENTS)

Manufactured by

Sheet Steel Products Company, **Michigan City, Ind.**

Sold by

Rich Tool Company

Valve specialists in silcrome and other alloy steels

1501 E. Ferry Ave. **Detroit, Mich.**

Functioning of Cooling Systems Assured in Coldest Weather

Eight billion dollars are being spent annually in the purchase and maintenance of automobiles. Yet many car owners do not have year 'round use of their cars, due to their frozen radiators.

With Chromine in the cooling system, no motorist need forego winter driving. Nor, is there any need for trucks and other commercial cars to be out of commission in zero weather.

Chromine REG. TRADE MARK

A Patented Solution which Prevents Frozen Radiators. Successfully used for the past five years.

RADIATOR FREEZE-PROOF

First Cost
The Only Cost

One Charge
Lasts all Winter

THOUSANDS of motorists are getting more service out of their automobiles during winter months because their cars are protected with Chromine —the reliable radiator freeze-proof solution. Until recently many car owners put their cars up for the winter rather than have the worry of frozen radiators and water jackets because of unheated garages or other exposure of their cars in cold weather. Chromine makes heated garages unnecessary.

With Chromine in the radiator, car owners can be assured the use of their cars on coldest days. Or, if cars are not in use, they will know the danger of a frozen cooling system has been eliminated, at a trifling cost. With Chromine, the first cost is the only cost, for one charge lasts a whole season.

Motorists will find Chromine the most satisfactory and economical radiator freeze-proof solution they can use. It has been used with uniform success for five years.

Chromine was developed by Miller Reese Hutchison, Ph. D., inventor of the Klaxon horn and many other notable devices.

Sold in 55 Gallon Drums through automotive jobbers and dealers

Manufactured exclusively by

PYRENE MANUFACTURING COMPANY

Makers of Pyrene Extinguishers and **OFF'N'ON** *Tire Chains*

560 Belmont Avenue Newark, N. J.

RELLEUM Brass Forgings

for Vital Automotive Parts

Mueller Products

Red Tip Brass Rod
Relleum Brass Forgings
Niag Nickel Silver Rod
Sancraft Brass Castings
Brass Screw Machine Parts
Blue Tip Tobin Bronze Rod
Brass and Copper Seamless Tubing
Mueller Tobin Bronze Welding Rod

MUELLER BRASS CO.

Port Huron, Mich.

Associated with Mueller Co., Decatur, Ill.
In Canada, Mueller, Limited, Sarnia, Ont.

Offices:

New York Philadelphia Pittsburgh Cleveland
Detroit Buffalo Chicago Indianapolis

World's Largest Manufacturers of Brass Forgings

MUELLER BRASS

TRADE *Pantasote* MARK

The Standard Seating Material of 90% of the Country's Railroads

No wonder! Pantasote has been in use in some cars as long as thirty years and it is still good.

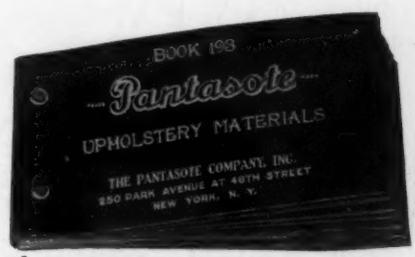
Do not confuse Pantasote with ordinary "imitation leathers." It is made by a process basically different from any other leather substitute. To that fact is due its extraordinary wearing qualities.

Fire resistant, washable, it will not crack or rot. Pantasote withstands the hardest wear and abuse.

The finest of colors and grains can be had in Pantasote, to blend with any bus finish.

This book . . . . . .

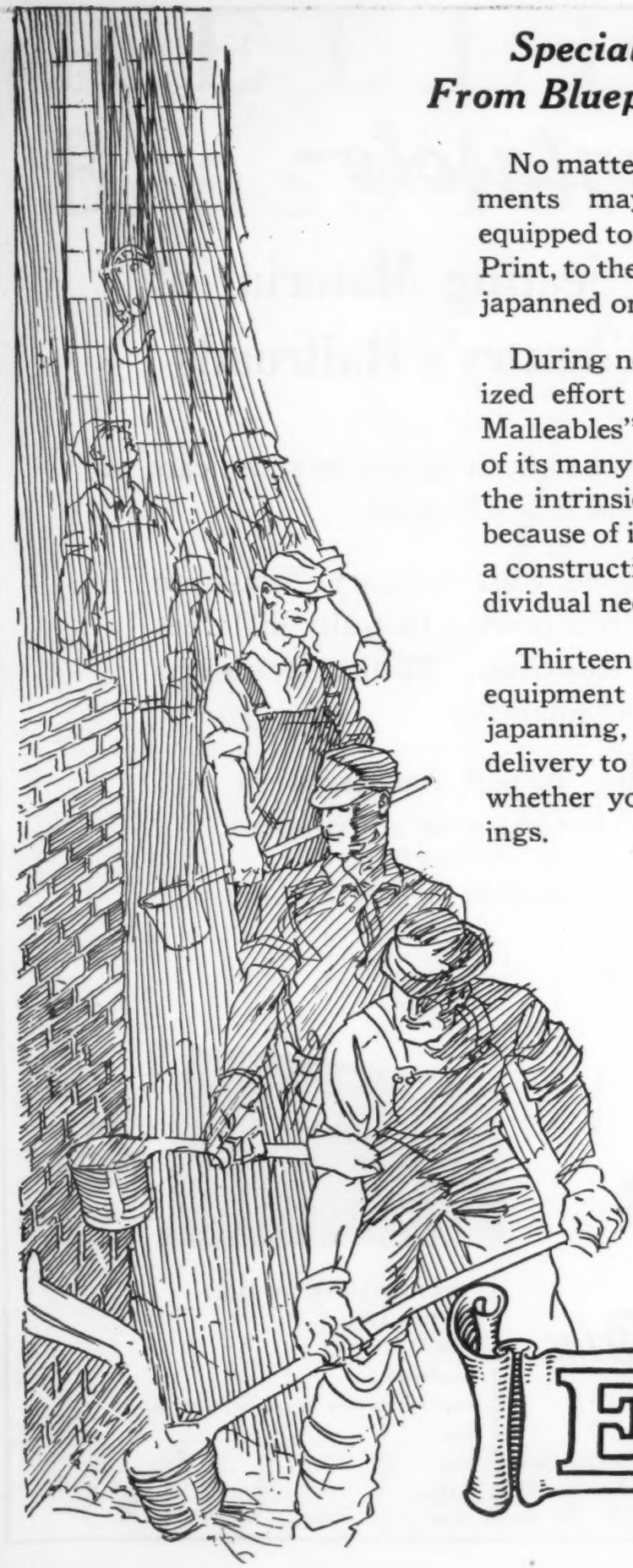
containing all the beautiful new colors and finishes will help you choose a material beautiful as well as durable.



Send for it TODAY

The PANTASOTE Co Inc
250 Park Avenue
NEW YORK CITY

THE PANTASOTE CO., INC.
250 Park Ave.
New York City
Gentlemen:
Send me the new Pantasote Sample Book.
Name .....
Firm .....
Address .....



Special Vehicle Malleables From Blueprint to Finished Casting

No matter what your malleable requirements may be, this organization is equipped to meet your needs from the Blue Print, to the pattern, to the fully machined, japanned or plated casting.

During nearly a half century of specialized effort in the production of "Better Malleables" it has gained the confidence of its many customers, not only because of the intrinsic value of its Product but also because of its sincere desire to cooperate in a constructive way to better meet each individual need.

Thirteen acres of floor space, modern equipment and facilities for machining, japanning, or plating will assure prompt delivery to meet your production schedule, whether you want plain or finished castings.

Trade E Mark

The Eberhard Manufacturing Company

2734 Tennyson Road
Cleveland, Ohio

EMCO

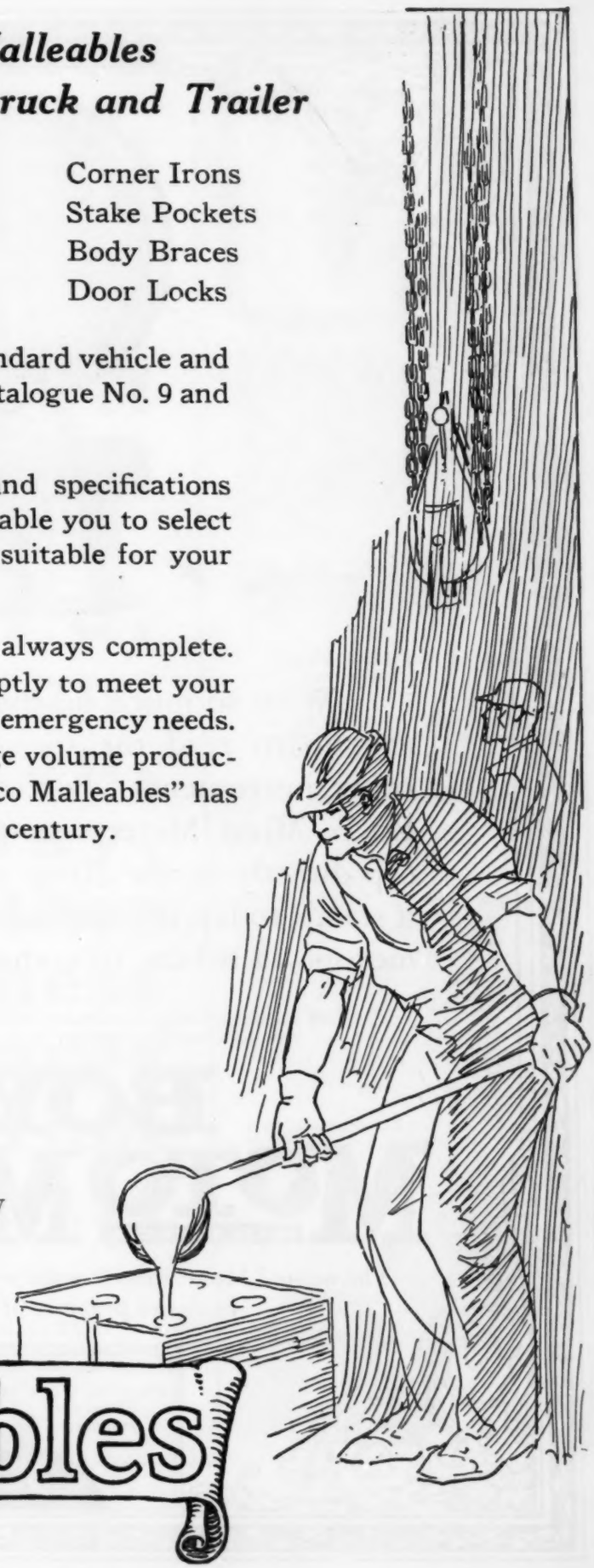
Standard Vehicle Malleables For Bus, Passenger Car, Truck and Trailer

Seat Irons
Bus Door Controls
Coach Hinges
Windshield Hinges
Corner Irons
Stake Pockets
Body Braces
Door Locks

—and many other types of standard vehicle and body irons are shown in our catalogue No. 9 and Supplement.

The detailed illustrations and specifications given in these catalogs will enable you to select the types of body irons most suitable for your needs.

Our stock of these irons is always complete. Shipments can be made promptly to meet your standard requirements or your emergency needs. Prices are consistent with large volume production—and the Quality of "Emco Malleables" has stood the test for nearly a half century.



Trade E Mark

The Eberhard Manufacturing Company
2734 Tennyson Road
Cleveland, Ohio

Malleables

With so much on the dash it's all the driver can do to read the speedometer, let alone the other instruments. Foreseeing this, the original Boyce Moto Meter was placed on the radiator cap directly in the driver's line of vision. There it stands today, the constant guardian of 8,000,000 motors—a tribute to common sense engineering.

THE MOTO METER COMPANY, INC., LONG ISLAND CITY, N. Y.
THE MOTO METER COMPANY OF CANADA, LTD., Hamilton, Ontario

BOYCE MOTO METER

TRADE MARK REG. U. S. PAT. OFFICE

The name "Moto Meter" is the registered trade-mark and the exclusive property of this Company

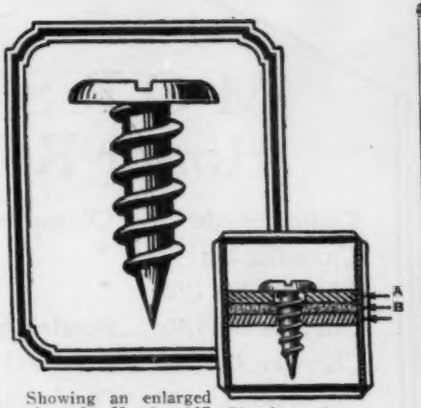
Body Assemblies Are Made Better, Quicker and Cheaper With

PARKER-KALON

HARDENED SELF-TAPPING Sheet Metal Screws

(PAT. APRIL 1, 1919 — MARCH 28, 1922
AUGUST 14, 1923 — FEBRUARY 10, 1925)

Would Ford, Dodge, Hudson, Paige, Jordan, Briggs, Murray, Seaman and other leaders use these Screws on a large scale if they did not get such results?



Showing an enlarged view of a No. 8 x 5/8" Hardened Self-Tapping Sheet Metal Screw with a special binding head. This particular screw is being used in large quantities by automobile manufacturers and body builders for fastening down upholstery.

Showing how upholstery fabric is fastened to auto bodies with Hardened Self-Tapping Sheet Metal Screws. (A) Upholstery strip; (B) upholstery fabric; (C) steel pillar.

A few of the many applications for which PARKER-KALON Hardened Self-Tapping SHEET METAL SCREWS are being used by automobile manufacturers and body builders:

Fastening upholstery to doors and body panels;

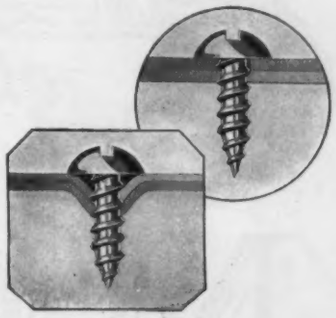
Attaching scuff plates, trim sticks, weatherstrip, moulding, anti-squeak, etc., to auto bodies;

Fastening metal finger lifts to windshields.

PARKER-KALON Hardened Self-Tapping SHEET METAL SCREWS are steel Screws, designed expressly for sheet metal work. They cut a thread in sheet metal, like a tap, as they are being screwed in, without stripping their own thread, thereby completely eliminating the troublesome and expensive tapping operation with its breakage of taps and upkeep of tapping machinery.

Hardened Self-Tapping Sheet Metal Screws can be used successfully in all gauges of sheet steel lighter than 14 gauge.

Made in a number of stock sizes. Can also be furnished in any special size and with any style of head.



Hardened Self-Tapping Sheet Metal Screws can be used in clean punched or drilled holes as shown in the upper illustration or in holes pierced with a burr as shown in the lower picture.

WRITE FOR SAMPLES AND FULL INFORMATION

Look into the time-and-labor-saving possibilities of these unique Screws. Any application you may develop for them is sure to result in worthwhile economies for you.

PARKER-KALON CORPORATION

358 West 13th Street New York

MORSE Honor Roll

Cadillac Eight	Oldsmobile Six
Chandler Six	*
Chrysler Six (70)	*
Chrysler Six (80)	Peerless Six (72)
Chrysler Six (60)	Peerless Six (80)
Cleveland Six (31)	Pontiac Six
Cleveland Six (43)	Rickenbacker Six
Davis Six (92)	Rickenbacker Eight
Davis Six (93)	Star Four
Diana Eight	Star Six
Essex Six	Stearns K Four (B)
Fiat Six (5-90)	Stearns K Six (75)
Flint Six Jr.	Stearns K Six (95)
Flint Six (60)	Continental Motors

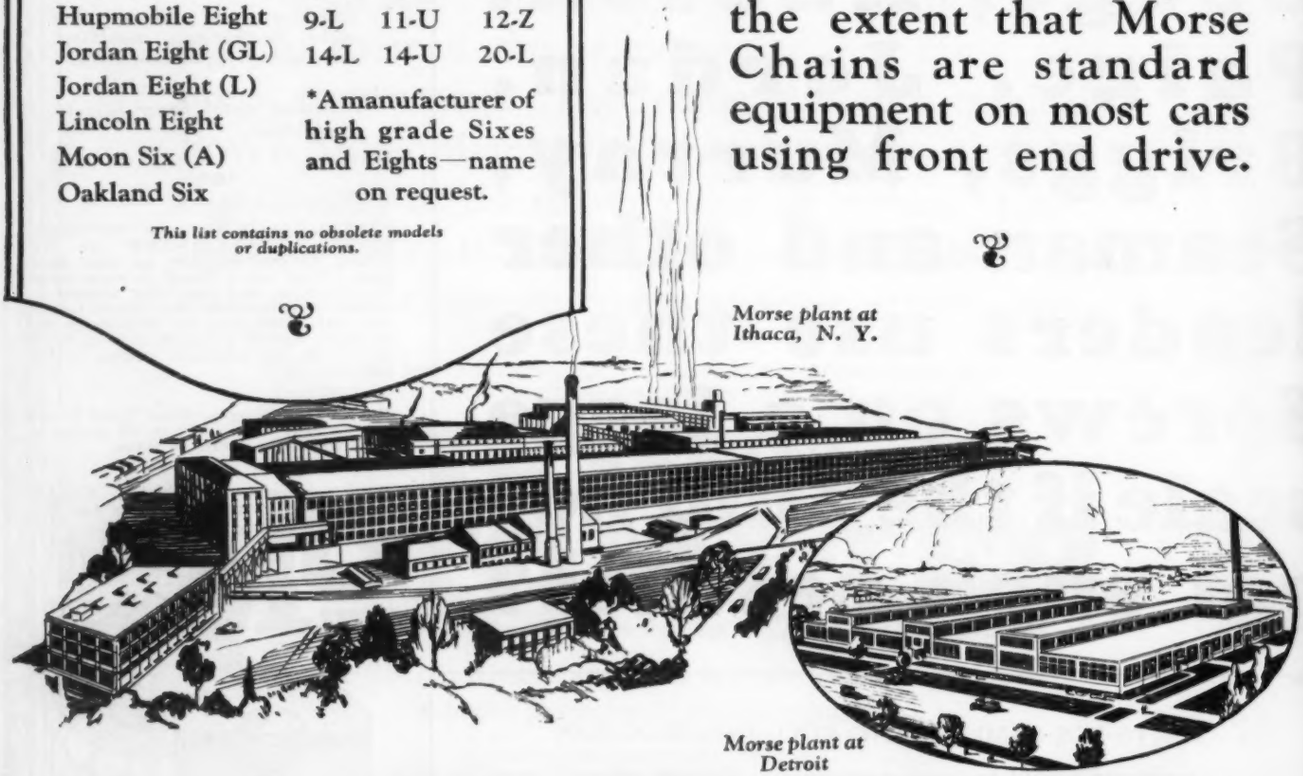
Engine	Models	W-S
6-E	7-U	72
8-S	8-U	9-K
9-L	11-U	12-Z
14-L	14-U	20-L

*A manufacturer of high grade Sixes and Eights—name on request.

This list contains no obsolete models or duplications.

WITH a daily production of over 5,000 chains and 10,000 sprockets — the Morse Chain plants at Ithaca, N. Y. and Detroit keep pace with the production schedules of the Motor Car industry.

This extensive plant capacity plus the acknowledged superiority of Morse Silent Chains are appreciated by the Automotive industry to the extent that Morse Chains are standard equipment on most cars using front end drive.



Morse plant at Ithaca, N. Y.

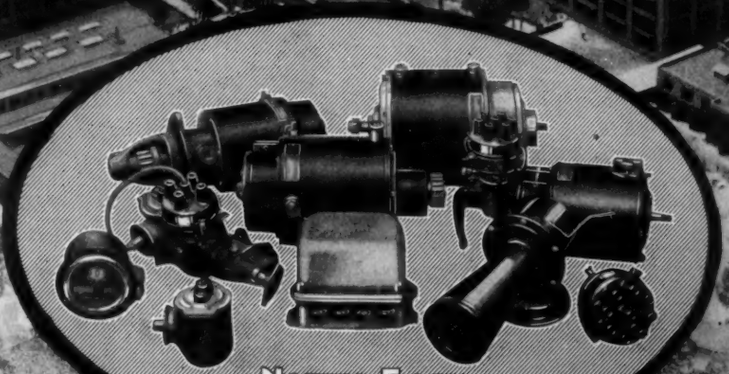
Morse plant at Detroit

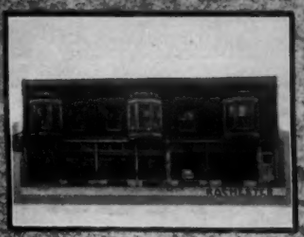
MORSE

GENUINE SILENT CHAINS

NORTH EAST

Electric Starting Lighting Ignition Horns Speedometers





NORTH EAST ELECTRIC CO.

ROCHESTER, N. Y., U. S. A.

Starter-Generators Generators Starting Motors
Ignition Units Ignition-Generators Switches Cut-Outs
Control Units Horns Speedometers
Fractional H. P. Motors

The Standard for Dependability and Long Life

Manufacturers of Equipment for

DODGE BROTHERS REO GRAHAM BROTHERS
YELLOW CAB YELLOW COACH MACK
BERLIET STERLING MARINE ENGINE WHITE
SAFEWAY SIX-WHEELER FIFTH AVENUE COACH DODGE WATERCAR
YELLOW SLEEVE VALVE ENGINE DELAGE ACME ROAD MACHINE
FAY AND BOWEN FOUR WHEEL DRIVE MORELAND
AMERICAN LA FRANCE HOLT CATERPILLAR TRACTOR

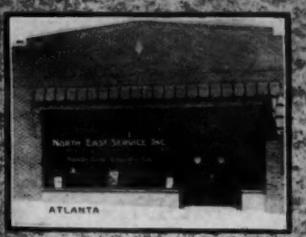
NORTH EAST SERVICE INC.

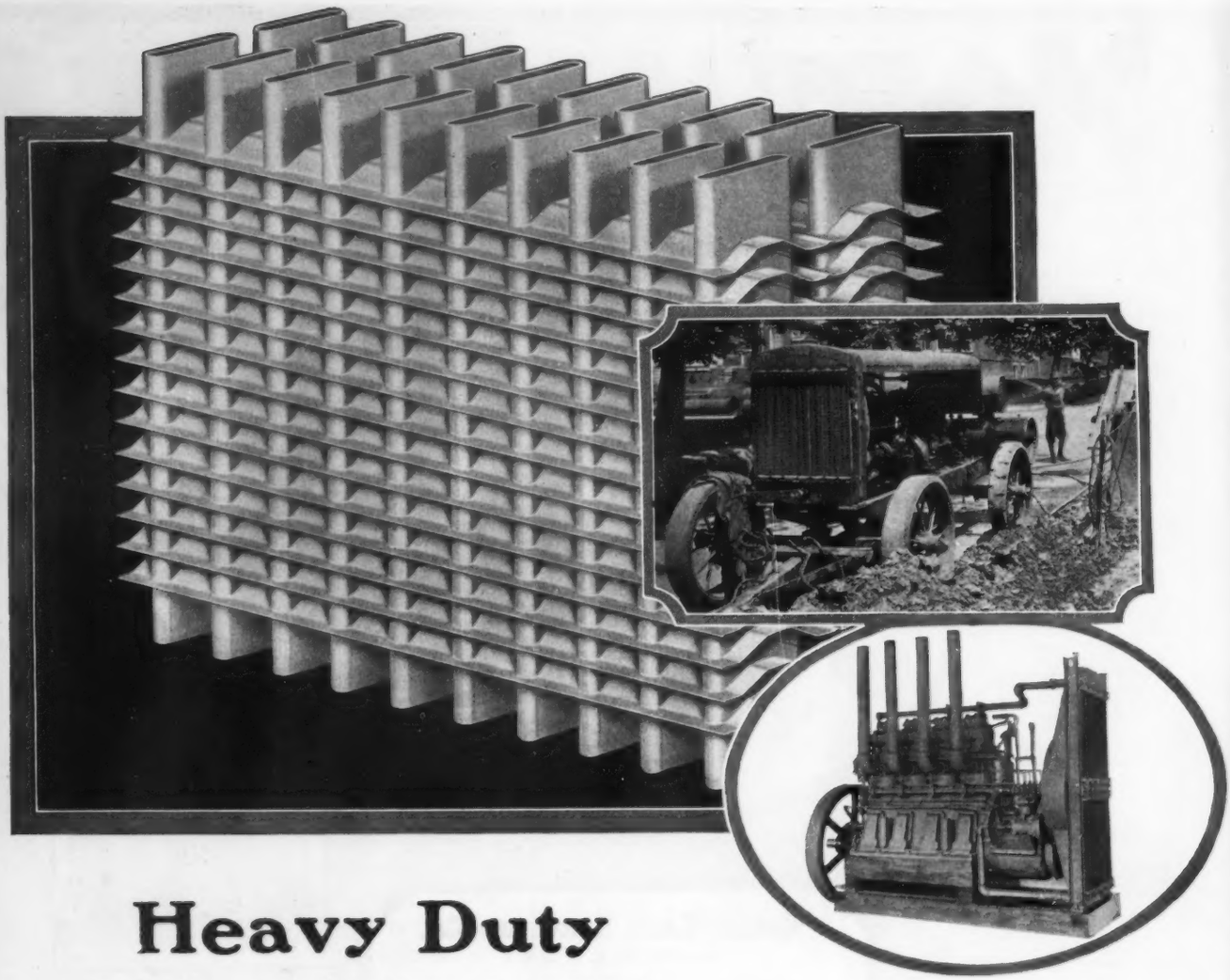
ROCHESTER, N. Y.

Official North East Service Organization

Atlanta London New York
Chicago Paris Rochester
Detroit San Francisco
Kansas City Toronto

Service Stations in Cities of Importance throughout the World





Heavy Duty

Turbotube—made only by Modine—has estab'ished an unmatched record for cooling efficiency as applied to engineering units of heavy duty type.

Combined with the advantages of high-cooling capacity are extended limits in strength, light weight, and free, unrestricted water circulation.

These qualities are so outstanding that leading producers of heavy duty machinery adopted Turbotube as indispensable to the efficiency of their product.

Present your cooling problems to us no matter how complex they may be. We can solve them.

Top: Ingersoll-Rand Type 20 Air Compressor using Turbotube as standard equipment.

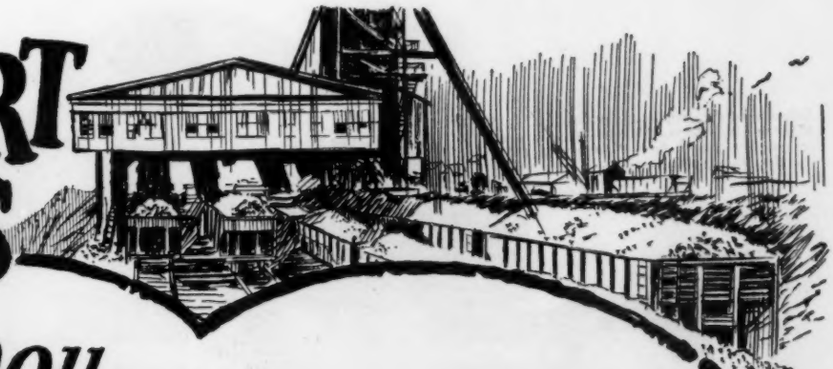
Below: 60 H.P. Fairbanks-Morse Engine cooled with Turbotube.

MODINE MANUFACTURING CO.
Racine, Wisconsin

1 to 1000 H. P. any type—Tubular or Cellular (Spirex)—Sectional — Conventional Cost—Sheet metal, or if preferred only cases or sections.

MODINE RADIATORS

from the HEART of the HILLS to you



"NACCO" CLEAN COAL

Premier Coal for Every Industrial Purpose

Mines in all the principal Bituminous Districts producing the highest grades of Steam, Malleable and Gas Coals, specially prepared to meet the requirements of the Automotive Industry.

FIFTEEN MILLION TONS ANNUALLY

A TRIAL ORDER WILL CONVINCE YOU OF THE SUPERIORITY OF OUR PRODUCT

Pittsburgh Terminal
Youghiogheny Gas

Atwater Pocahontas
Powhatan

Logan County, W. Va.
Gas, By-Product
and Steam

Pittsburgh Steam
Pittsburgh No. 8

15,000,000 Tons Annually

The NORTH AMERICAN COAL CORPORATION

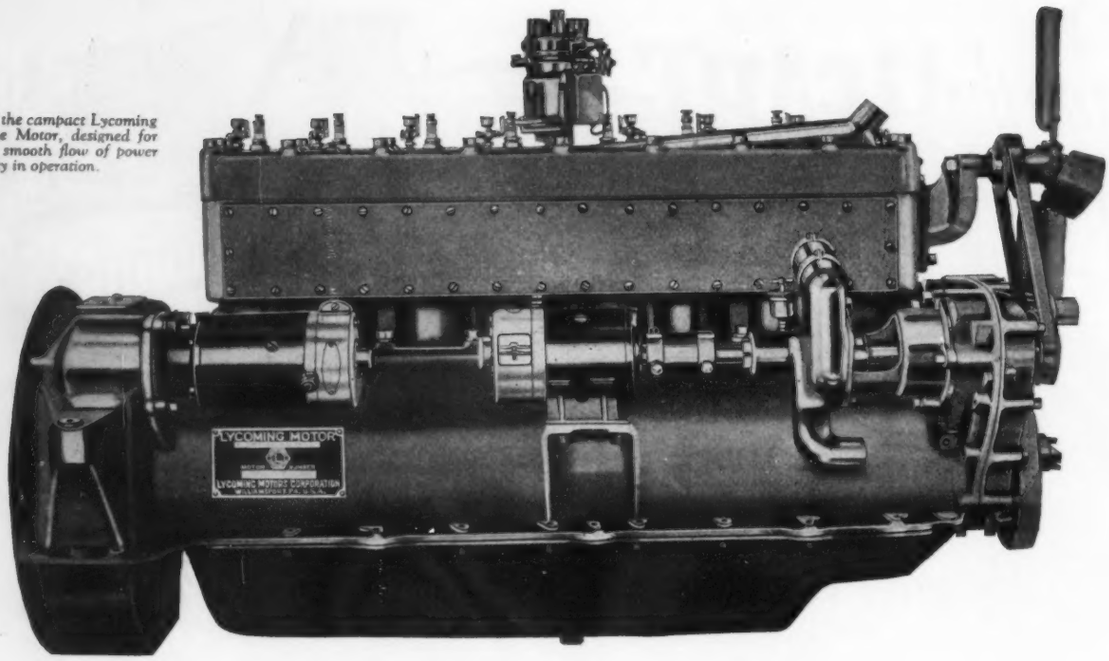
UNION TRUST BLDG
CLEVELAND • OHIO

Prudential Building
Buffalo, N. Y.

Wabash Building · *Pittsburgh, Pa.*
No. 1 Broadway *New York City*

Second National Bank Building
Toledo, Ohio

Second National Bank Building
Akron, Ohio



Side view of the compact Lycoming Eight-in-Line Motor, designed for accessibility, smooth flow of power and flexibility in operation.

THE proof of foresight in Lycoming design is nowhere better illustrated than in the present popularity of cars powered with Lycoming Eight-in-Line Motors.

The favor with which successive models of these cars were received by the public when first brought out has been reflected in the steadily increasing sales by the car makers.

When car makers are being forced to crowd production over a period of months in order to catch up with demand, it is evident that performance—which centers in the engine—is satisfying car owners.

The detailed description of the several models of the Lycoming Eight-in-Line Motor will be sent promptly on request to car manufacturers.

LYCOMING MANUFACTURING COMPANY
Makers of fine Fours, Sixes and Eights-in-Line
WILLIAMSPORT :: PENNSYLVANIA
Export Department—44 Whitehall Street, New York City
MEMBERS OF MOTOR TRUCK INDUSTRIES, INC., OF AMERICA

LYCOMING
Motors
Years Ahead in Automobile Motor Efficiency

THE consistent quality of our production, coupled with dependable service and low prices, has induced many of the leading automobile manufacturers to entrust their stamping work to us.

Engineers who are specialists in our line; forty years of varied experience; unexcelled mechanical facilities; large financial resources—these things are the tangible advantages we offer our customers.

MULLINS

MULLINS BODY CORPORATION
Main Office and Factories
Salem, Ohio

Detroit Office
5-139 General Motors Bldg.

When is oxygen cheap?

CHEAPNESS is relative and depends entirely on how much material, quality and service you get for your money.

Linde Oxygen—for years industry's standard—is sold on a basis of ultimate economy. Linde service, which goes with Linde oxygen, is designed to give to every customer the latest and best information on the use of the oxy-acetylene process. Service men, engineers, consultants, research men, are constantly at work and always at your service to show the latest methods, new applications and greater economies in welding and cutting.

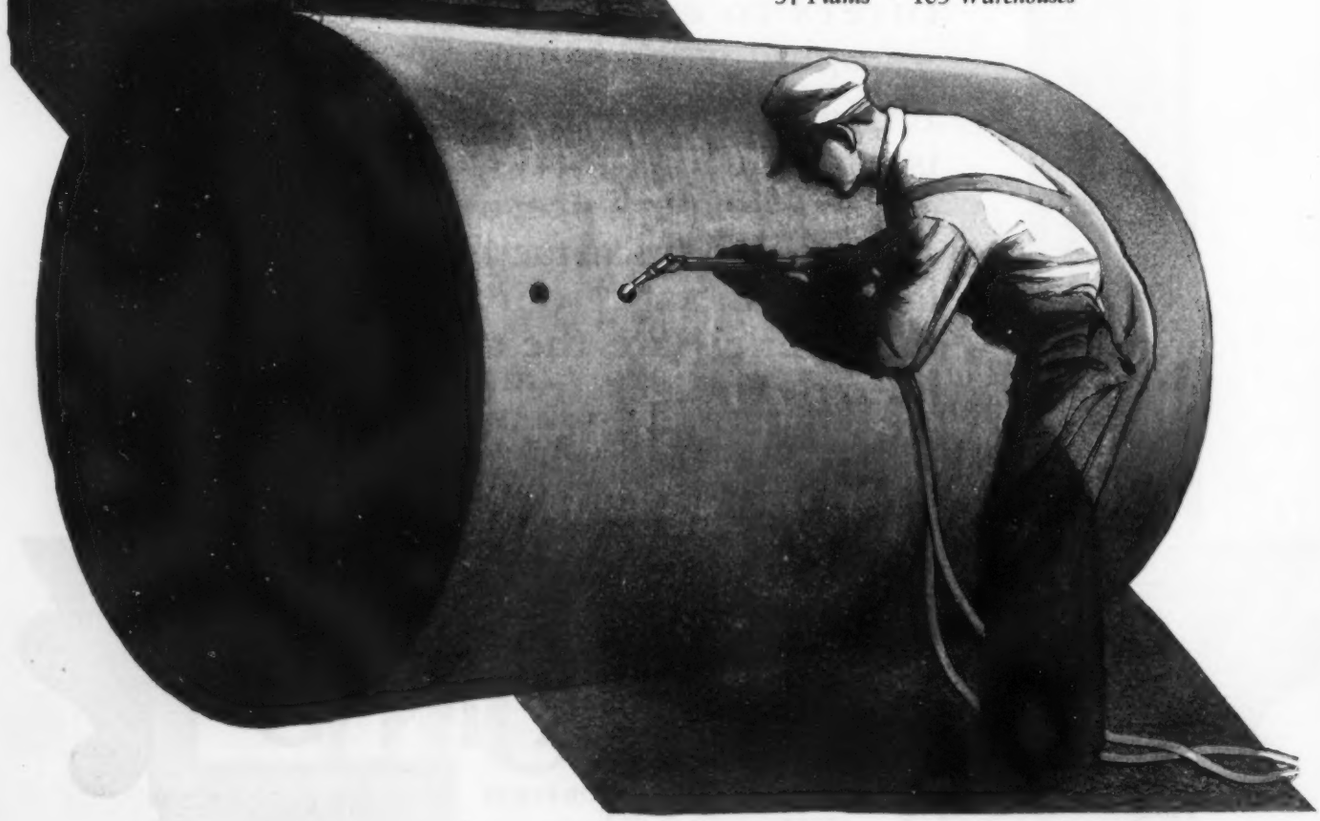
NOT ONLY can you build new tanks advantageously by welding, but old tanks that have given way on the bottom or on the crown can be repaired and reconditioned. Linde Methods tell you how to replace a bottom or a crown by the oxy-acetylene process and Linde engineers can give you suggestions even on design.

THE LINDE AIR PRODUCTS COMPANY

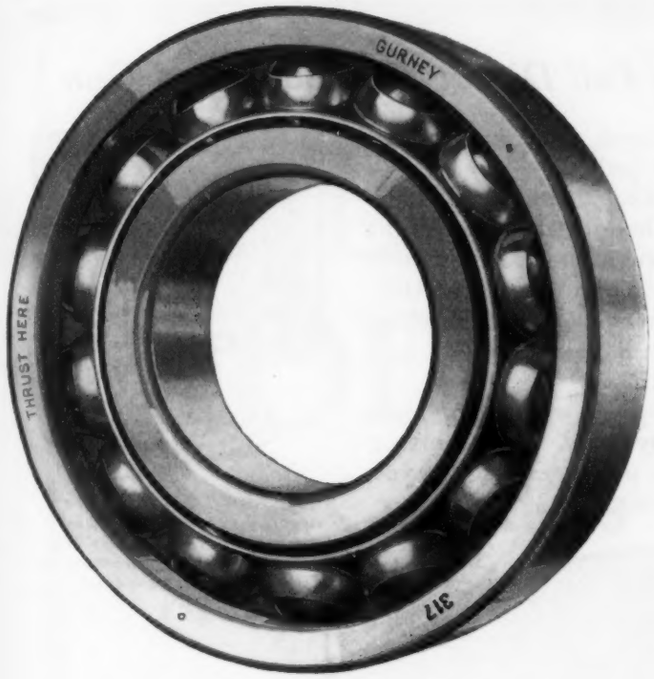
Manufacturers of oxygen, nitrogen, pyrogen, argon and neon
Producers of helium for scientific purposes

General Offices: Carbide and Carbon Building
30 East 42d Street, New York

37 *Plants* · 105 *Warehouses*



LINDE OXYGEN



The Pioneer Maximum Type Ball Bearings

For more than twenty years the name Gurney has stood for the Maximum in Load Carrying Capacity. This is made possible by using the maximum number of balls of the maximum size in uninterrupted raceways of the closest permissible curvature.

Molybdenum Steel Balls, now standard in all Gurney bearings, give considerably greater capacity. A comparison of load ratings will prove these statements.

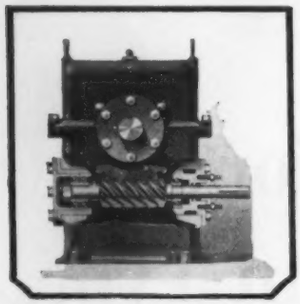
Send for new Data Sheets—just issued—giving load ratings and dimensions of Gurney Maximum type bearings.

MARLIN-ROCKWELL CORPORATION
Gurney Ball Bearing Division
JAMESTOWN - - - N. Y.

18353

GURNEY BALL BEARINGS

Neither Sudden Shocks Nor the Long Pull Distort This Alloy Steel Gear



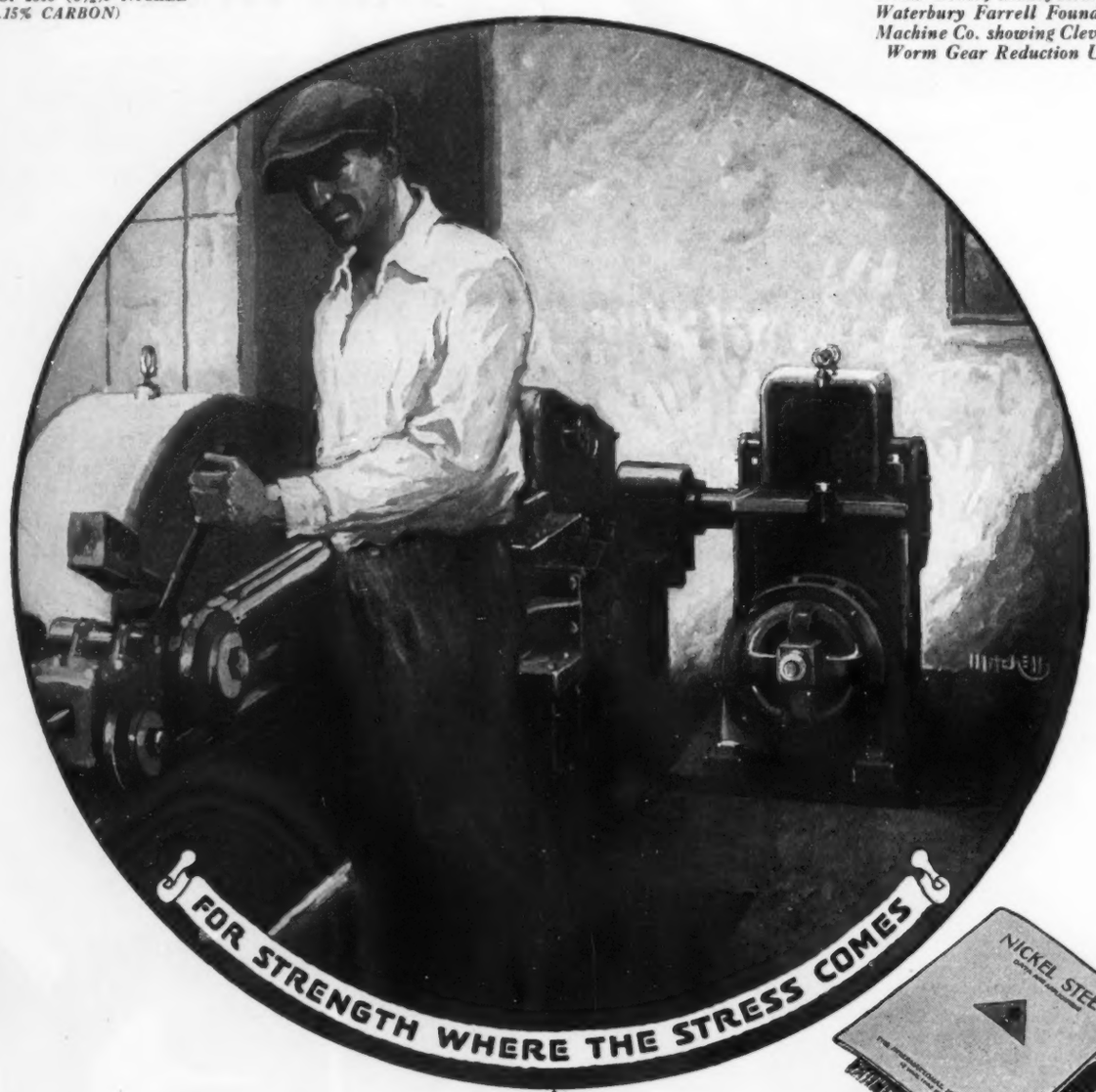
Cut-away view of Cleveland Worm Gear Reduction Unit showing worm made of CASE-HARDENED S. A. E. NICKEL STEEL NO. 2315 (3½% NICKEL —.15% CARBON)

WHEN this draw bench functions, there's stress—shocks and pull on every part—particularly on the gear between motor and chain.

Because there is stress—because there are shocks—because there is wear—engineers specified Alloy Steel for the worm gear. They knew that Alloy Steel has greater strength, toughness and ductility. They knew that Alloy Steel resists shocks and stands up under unusual stresses.

Wherever a product requires a tougher, more ductile metal, specify Alloy Steel. In improving YOUR product why not let our engineers give you the benefit of their experience.

Eighty foot, 1,000 lb. Chain Draw Bench, manufactured by Waterbury Farrell Foundry & Machine Co. showing Cleveland Worm Gear Reduction Unit.



Send for data file on Nickel Steel. This permanent binder will be a valuable addition to your files. Write today, mentioning this publication.

ALLOY STEEL

INCO NICKEL

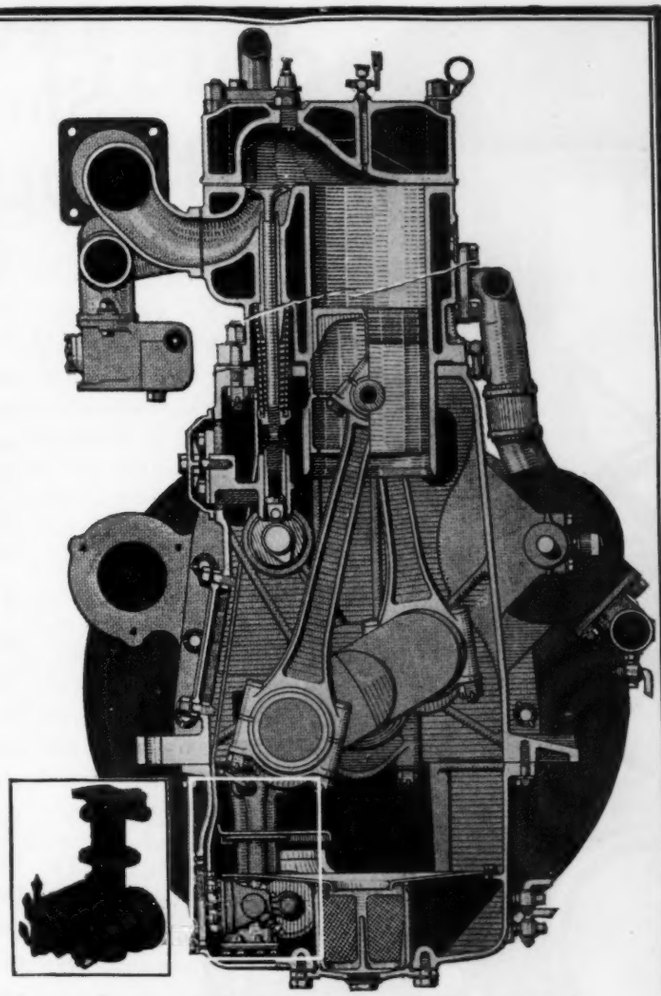
THE INTERNATIONAL NICKEL COMPANY, 67 WALL STREET, NEW YORK CITY.
Producers of INCO Nickel in all commercial forms

INCO NICKEL

FRESH OIL

for the Cylinders of Heavy Duty Motors

In heavy duty engine design, there is now a strong tendency towards systems of lubrication that provide fresh oil for the cylinders with re-circulated oil for the bearings only



The Madison-Kipp Lubricator [outlined by the white line] is shown here in the assembly of the Waukesha Motor. The lubricator, in the rectangle at the left, is also in scale showing the actual relation of its size to that of the engine.

SUCH a system, as used on the Waukesha Motor, is shown above, together with the Madison-Kipp Lubricator which provides fresh oil for the cylinders and pistons.

Long life in a heavy duty engine depends greatly upon the proper oil-seal for all bearing surfaces of the pistons and cylinders. The effectiveness of the oil-seal depends upon the quality of the lubricant *at the time it is delivered to the cylinders.*

Because Madison-Kipp Lubricators unfailingly deliver *fresh oil* in measured quantities to the cylinders, they effectively provide a proper oil-seal at all times, without the disadvantage of over-lubrication. They start with, and stop with, the motor, hence they function under all conditions of weather and engine performance without waste of oil.

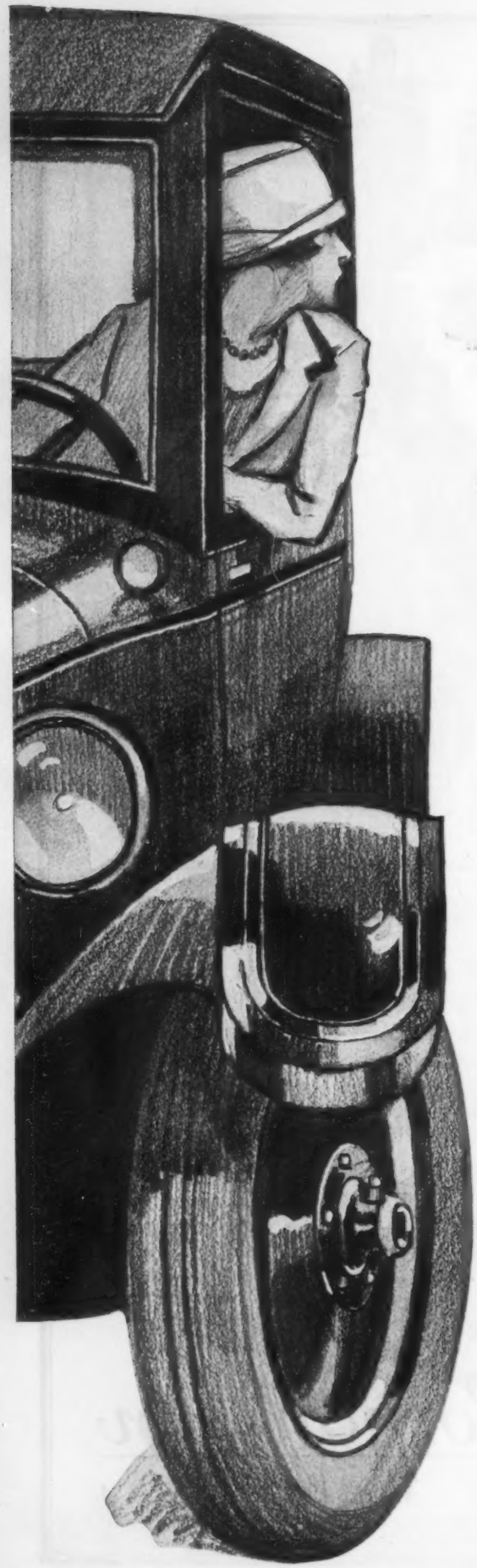
The addition of years of added motor life, made possible by the use of Madison-Kipp Lubricators, is one of the reasons why Waukesha and many other engine manufacturers, have adopted this system.

Our folders, "The Facts About Fresh Oil," deal with possibilities of this new system of fresh oil for the cylinders with recirculated oil for the bearings only. We will gladly send the complete series to anyone interested.

MADISON-KIPP LUBRICATORS

Madison-Kipp Corporation

Lubrication Specialists Since 1898 *Madison, Wisconsin, U. S. A.*



Leverage Lengthens and Shortens as Resistance Increases and Decreases

Vibrationless engines, longer springs, softer tires—clearly the trend in automotive design is toward greater riding comfort. Now the driver, too, can be made happier—by smoother, easier steering control. The Hannum Steering Gear conquers the troublesome forces of steering resistance with the new Hannum principle of variable leverage.

The steering resistance encountered in straight road driving is so different from that which prevails in parking and other low speed maneuvers, that Hannum engineers saw the need for going beyond the old designs which provided only the same leverage for all conditions. Steering leverage which is long enough to relieve the driver's arms of strain in parking is entirely too long to permit nimble control at high speed, where the steering angles are relatively small. The Hannum Gear meets this very situation by lengthening or shortening its leverage progressively, in direct proportion to the steering angle.

It is a simple and effective solution of a major problem in steering control, which became critical with the advent of balloon tires. An investigation of the theory, action and construction of the Hannum Steering Gear is wisdom in today's fiercely competitive market.

HANNUM MANUFACTURING CO.
MILWAUKEE

HANNUM STEERING

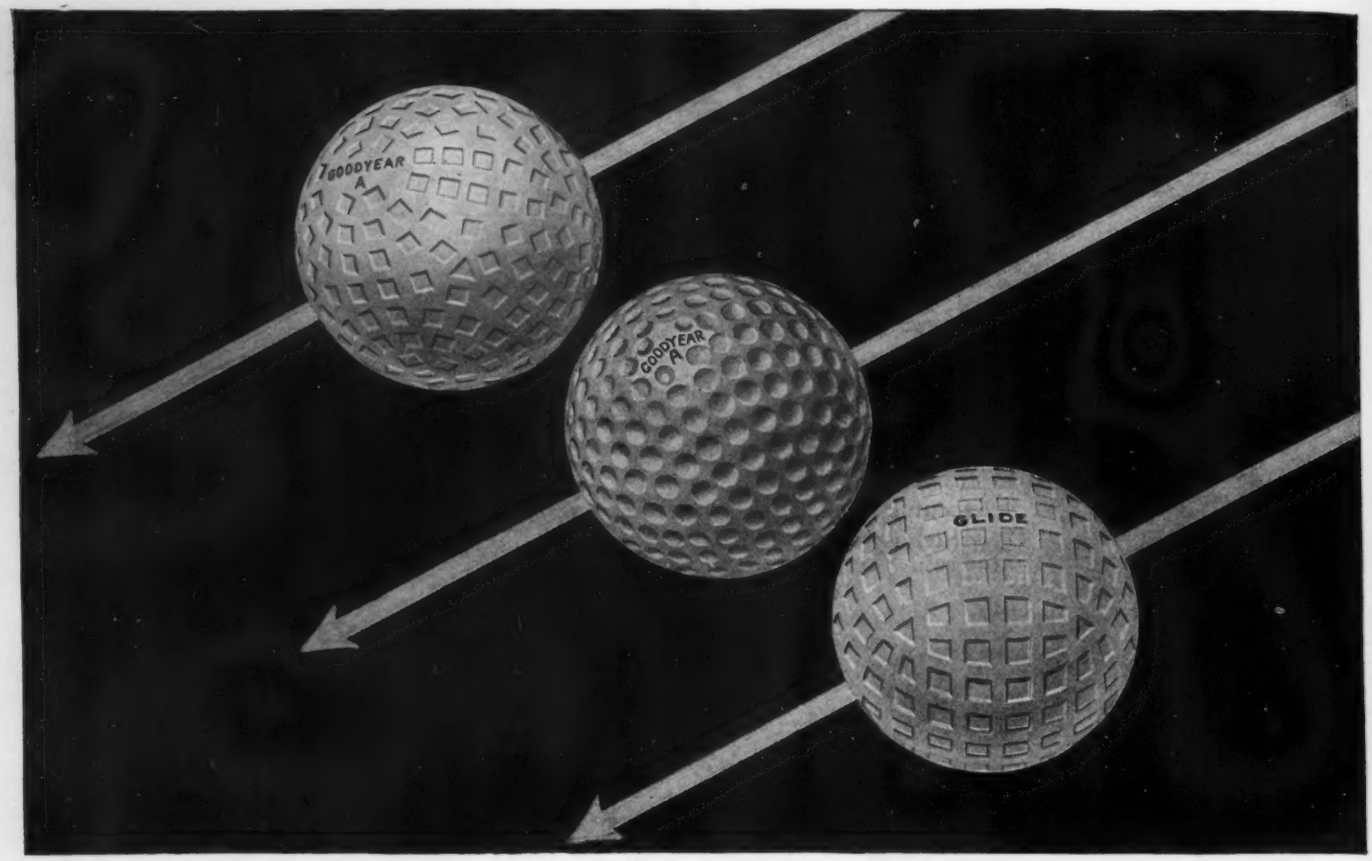
Any Shape or Height Nut—Any Size Hexagon from 5/8" Up

NO matter what size hexagon Acorn nut you need we can supply it to you promptly and always with assurance of highest quality. We are prepared to furnish a full range of sizes from 5/8" across the flats up. In precision and finish as well as in their special feature of smooth steel caps Wise Acorn nuts are unequalled in the industry. Engineering excellence plus economy is assured to the user of these nuts. Millions of them are already in use in automotive and other products where their accuracy as well as their fine appearance have been amply proven in gruelling tests of actual service.

Note how great a saving in cost we make over the ordinary Acorn nut cut from solid bar stock. In addition, our product can be furnished to you in any shape or size you may specify. We are not limited to any particular style of crown. The use of the full thread, bar stock base and heavy steel caps gives it rugged strength. The bases may be chamfered, counter-bored or furnished with washer face. Because of the smooth-surfaced caps used, finishing costs are lower; there being no tool marks to polish off. Our plant is equipped to render complete service, whether a plain or a finished nut is desired. All operations including nickel-plating or sherardizing are performed by one organization.

Write for samples

THE WISE INDUSTRIES
1033-43 Mt. Elliott Avenue
Detroit, Mich.



Lowered Prices on Goodyear Golf Balls

Goodyear 75c Glide 50c

Golfers everywhere will welcome the lowered prices on Goodyear Golf Balls.

The savings effected by a record breaking volume of sales and the consequent economies of large production are being passed on to golfers, resulting in the lowest prices at which Goodyear Golf Balls were ever sold.

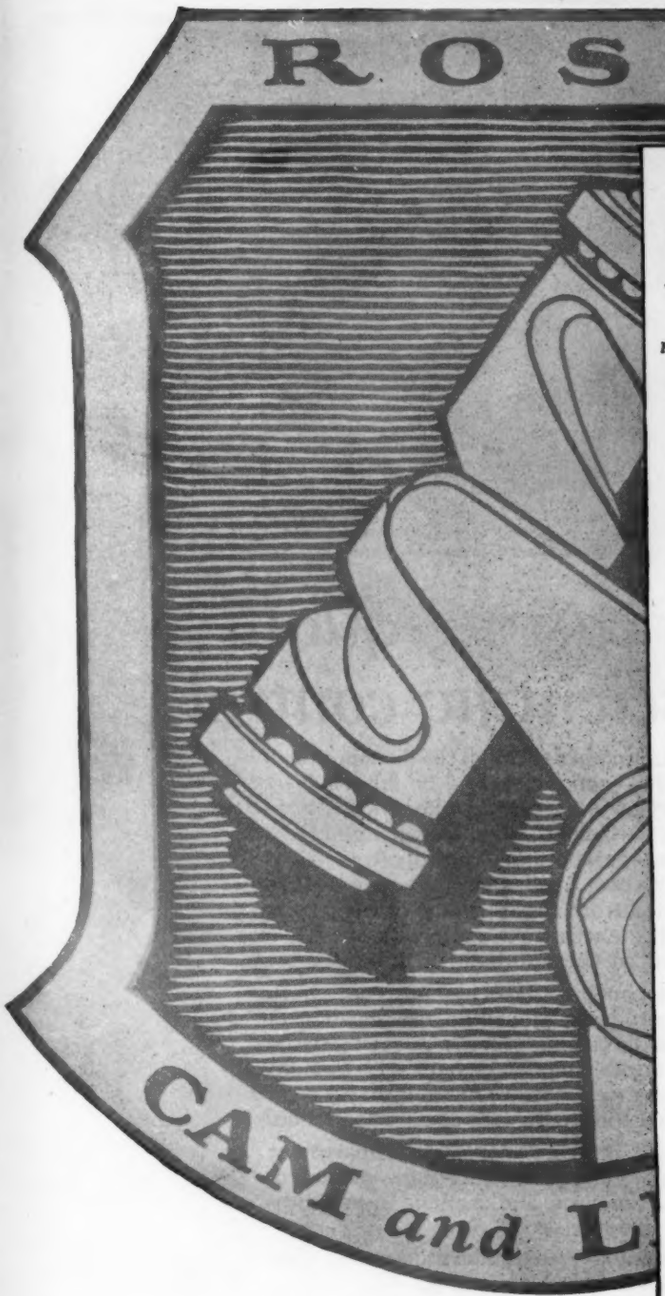
The Goodyear, in either mesh or dimple marking, is now 75 cents. The Glide, in mesh only, is 50 cents.

Both of these good golf balls are made by the makers of Goodyear Tires. Ask your professional or write to Goodyear, Akron, Ohio, or Los Angeles, California.

In Golf Balls, too

GOODYEAR

Means Good Wear



This advertisement appears in
THE SATURDAY EVENING POST
JUNE 5, 1926

EASIER STEERING · LESS ROAD SHOCK

Handles Your Car Like an Invisible Giant

New Protection and Ease for Your Family

When you are driving with your family—or when *they* are out in the car—there is vast satisfaction and comfort in the greater degree of safety brought you by the Ross Cam and Lever Steering Gear . . . Ross helps *handle* your car, keeps it true on straightaways, holds it steady in loose gravel and sand, protects against jolts and jerks at the wheel on rough roads. . . . All the great double-decked buses built in America use Ross for the safety of their passengers, as well as for easier steering. Your family should have this same protection. Ross is standard equipment on more makes of cars, buses and trucks than any other gear.

It's All in the Cam and Lever

You can do things easily with a lever that you can't do at all without it. Everyone knows this. The long lever in the Ross Cam and Lever Steering Gear is the source of the tremendous power that makes Ross steering so easy. And the cam with its variable pitch constitutes the almost impassable barrier to road shock that makes Ross Steering so safe and so comfortable!

Mail the coupon below for FREE booklet "Efficiency in Steering" and list of Ross-equipped cars.

Ross Gear & Tool Co., Lafayette, Ind.

ROSS
CAM *and* LEVER STEERING GEARS

EASIER STEERING LESS ROAD SHOCK

ROSS GEAR AND TOOL COMPANY, Lafayette, Indiana

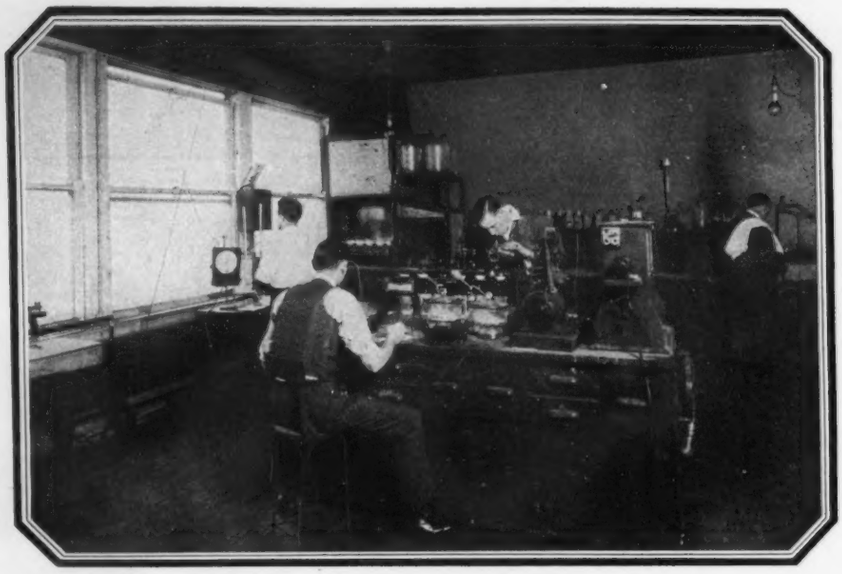
Please send me your FREE booklet, "*Efficiency in Steering*", which explains fully the Ross Cam and Lever principle.

Name.....

Address.....

If you are interested in the Ross Cam and Lever Steering Gear for replacement on Ford cars, put a check mark in this space. ☐

Car owner ☐ *Car dealer* ☐ *Automotive jobber* ☐



A corner of the Stewart chemical and metallurgical laboratory where analysis of raw materials and alloys and regulation of processes govern production

Maintaining die casting quality by scientific control

PART of the economy of die casting comes through the distribution of costs over a large production. This economy would be false indeed, if it involved a sacrifice of quality or uniformity. Uniform quality of Stewart Die Casting is maintained scientifically. A staff of chemists and metallurgists determines formulae and keeps laboratory control of metals and processes. Alloys are made only from the best quality virgin metals. Metals are analyzed on receipt and compounded from the formulae of the metallurgists. The alloys are then analyzed to check their composition and are released directly to the machines only on the approval of the chemists.

The specialized experience of the Stewart engineers has in many cases been effective in improving manufacturers' products by skillful modification of design and practical adaption of it to the die casting process. A saving to the Stewart customer is accomplished by a die making department with modern equipment and expert personnel that does excellent work without undue cost. The customer is charged only the actual tool room cost of die production.

The vigilance and thoroughness of the Stewart inspection department make it next to impossible for an imperfect casting to escape detection. Faults in casting immediately eliminate the piece, and castings imperfectly finished are returned for correction or scrapped.

The complete Stewart service has advantages to the manufacturer that will be taken up in detail, without obligation, at his request.

THE STEWART DIE CASTING CORPORATION
4500 FULLERTON AVENUE · · CHICAGO

Direct Factory Representatives in

Detroit Milwaukee
Cleveland Los Angeles
San Francisco
New York City
Birmingham Pittsburgh
Indianapolis St. Louis

Stewart

AEG-Gray

The Four Wheel Brake Has Come to Stay

Efficient four wheel brake operation demands a lining with a high and uniform co-efficient of friction because brake pedal pressure should be low and pedal travel within comfortable limits.

In addition, brake adjustment must be maintained as long as possible—which calls for a lining with slight compression and a low rate of wear. Uniform braking at all times, irrespective of atmospheric conditions, is another requirement.

Johns-Manville Engineers have been meeting problems for a long time in the use of friction materials for many purposes and their vast store of information is available for the asking. Have you a problem?

JOHNS-MANVILLE INC.
292 Madison Ave., at 41st Street, New York City

Branches in all large cities.
For Canada: Canadian Johns-Manville Co., Ltd., Toronto.

Through
Asbestos
and its allied products
INSULATION
BRAKE LININGS
ROOFINGS
PACKINGS
CEMENTS
FIRE PREVENTION PRODUCTS

JOHNS-MANVILLE
Automotive Equipment

TESTS TELL

Continually gaining is the high tide of public approval for Hayes Wheels with attached-lug rims. 10,000,000 motorists whose cars have been equipped with these wheels in the past 17 years know the implicit faith they can place in Hayes Wheels in an emergency due to their exceptional quality. 45,000,000 wheels placed in service represents a test never before paralleled in the history of the automobile industry. No wonder more and more motorists are specifying Hayes Wheels with attached-lugs on their cars.

"IT'S the little things that often cause the most annoyance, as anyone can tell you who has searched under the bureau for a lost collar button or dug in the mud for a loose lug. For anyone who wants to save his time and keep his temper, my recommendation is to be sure he has Hayes Wheels with attached-lug rims on his car. I did this when I bought my Flint because I realized LOOSE LUGS ARE BEHIND THE TIMES."

Union Trust Bank of Chicago

THE STORY

Motorists desiring *all* the modern conveniences want their cars to have *all the latest wheel improvements.* Everyone can readily understand that Hayes Wheels offer these definite and very decided advantages; distribute driving strains, save time in tire changes, save tire wear, save service expense, eliminate rim squeaks, eliminate torn valve stems. The only way for dealers to offer all of these advantages is to sell *only* cars having Hayes Wheels with attached-lug rims.

HAYES WHEEL COMPANY, *Manufacturers,* Jackson, Michigan

HAYES WHEELS

WITH ATTACHED LUG RIMS ~ STANDARDIZED IN WOOD, WIRE AND DISC

The first and final lesson
in the elements of spring control

Can anyone conceive of the possibility of flying an airplane if the elevator can be controlled in only one direction? Likewise, is there an Automotive Engineer who deems it possible to control the body of a motor car with respect to the axle without a rigid connection between the axle and the stabilizing element?

◆ ◆ ◆

The very idiosyncrasies of friction elements are well known to every motor car designer because of his experience with brakes. He admits the relative futility of such principle for true body control. Without argument, all engineers accept the hydraulic principle as a means of smooth, constant, reliable action of a calibrated character.

◆ ◆ ◆

The hydraulic control which gives free movement at center, and proportional resistance with movement from center, either way—up or down—and that has a rigid, ball-jointed connection between the axle and the device, makes its own theoretical appeal.

◆ ◆ ◆

But, after many years of development of the HOUDAILLE Hydraulic Control, based originally upon the recoil mechanism of the famous .75-millimeter gun, engineers who have carefully compared the performance of all devices for this purpose, have learned this lesson beyond all question of doubt.

◆ ◆ ◆

Some engineers, however, are astonished to find in the HOUDAILLE Hydraulic Shock Absorber, finer tolerances and more perfect machine work, necessitated by the problem itself, than any other part of their own well-built cars.

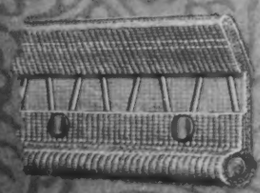
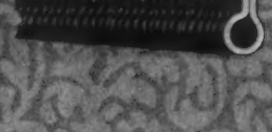
◆ ◆ ◆

There is a reason why Lincoln, Pierce-Arrow, Stearns-Knight, Cunningham and McFarlan use these comparatively expensive instruments. That reason lies in their construction, their theory and their unapproachable performance. Now made in several sizes for all types of cars.

THE HOUDE ENGINEERING CORPORATION

195 Winchester Avenue, Buffalo, New York

SERVING AMERICAS FOREMOST MOTOR CARS

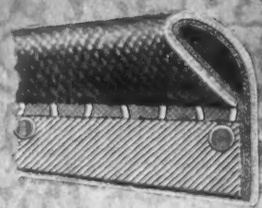
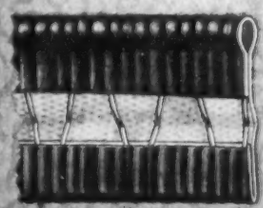



CARTER'S

WIRE ON PRODUCTS *for* OUTSTANDING SERVICE & DISTINCTION

Pioneers in the development of high class Trimmings and Mouldings, and sensing the requirements of the industry, The George R. Carter Company originated WIRE ON Mouldings. These products answer the industry's demand for better quality, ease in application, and refinement in appearance of trimmings. As requirements grew more exacting, Carter applied the basic "Wire On Principle" to a complete list of trimming essentials.

Our Staff is at your disposal in meeting your trimming problems

The Geo. R. Carter Co.
Connersville, Ind.

U. S. Patent Aug. 16, 1921; Canada Patent July 25, 1922
Foreign Patent Pending

—panels of PLYMETL did not fail—

A Skid—A Scrape—A Crash!

Accidents like this—which happened to a New Jersey bus traveling the White Horse Pike—are bound to occur.

They may be disastrous to the body—or, as in this case, the builder may have safeguarded the bus against such accidents by using PLYMETL side panels. As the Kuhlman Car Company writes, and the photograph shows, "The only place where damage occurred was where PLYMETL stopped and sheet steel began."

An investment in PLYMETL insures not only light weight, high insulating value, economy in finishing and in maintenance, but also a very high resistance against the shocks of traffic accidents. Even the corners can be made of PLYMETL within reasonable limits of curvature.

With these multiplied values in PLYMETL, it is not surprising that it should be the accepted standard by so many bus builders and operators.

Write for blue print booklet containing valuable engineering data on the use of PLYMETL in bus bodies.

HASKELITE MANUFACTURING CORPORATION
133 W. Washington St., Chicago, Ill.

Distributors:
Esdorn Lumber Co., 412-22 E. 110th St., New York City, N. Y.
Shadbolt & Boyd Iron Co., Milwaukee, Wis.
California Panel and Veneer Co., 955 S. Alameda St., Los Angeles, Cal.

HASKELITE

for roofs, decks, floors and linings—

The use of HASKELITE lowers the cost of labor and building, makes possible increased strength with reduced dead weight and consequently reduces operating cost. It is an important factor in providing increased head room with a lowered center of gravity.

Complete information on the use of HASKELITE in your bus bodies will be sent on request. Write for it.

PLYMETL

HIGH-GRADE

G&O Radiators

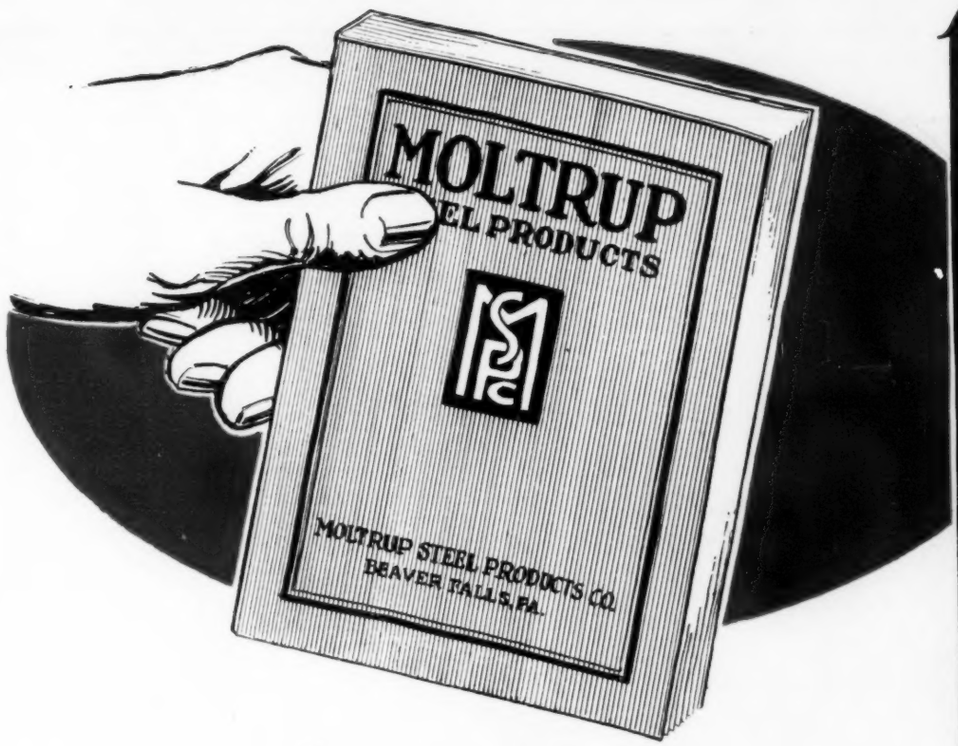
HONEYCOMB *and* TUBULAR

Large Manufacturing Facilities
Modern Equipment
Prompt Service

CORE
G&O Radiators
SERVICE

TENTH YEAR

THE G & O MFG. CO.
NEW HAVEN, CONN.



Send for This
NEW CATALOG

The Moltrup Steel Products Catalog No. 2 is a complete directory of information on Cold Drawn, Milled and Ground Specialties. It should be in the file of every executive responsible for the purchase of material of this character. *Ask us to mail your copy.*

We Specialize on the following Steel Products

Cold Drawn Steel in Rounds, Squares, Hexagons, Flats and Special Shapes.

Turned and Polished Shafting.

Free Cutting Screw Stock.

Special Polished Rod.

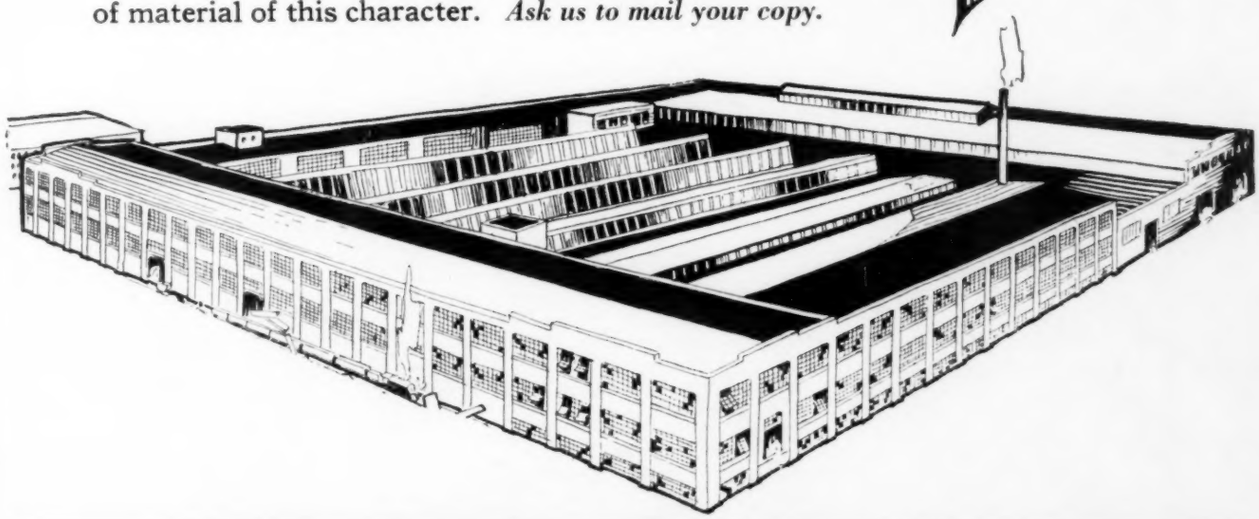
Machine Keys.

Woodruff Keys.

Machine Racks.

Flattened Steel Foundry Pattern Plates.

Ground Steel Plates for Various Uses.



Moltrup Steel Products Co., Beaver Falls, Pa.

District Offices—New York, Woolworth Bldg.; Boston, 80 Boylston St.; Buffalo, 303 White Bldg.; Portland, Oregon, 1207 Sandy Blvd.; Philadelphia, Pa., 1025 Drexel Bldg. *Sales Agencies*—Central Steel & Wire Co., Chicago and Detroit; H. D. Cushman Company, Cleveland; R. E. Murray & Co., 308 National Bank of Commerce Bldg., Norfolk, Va.

1,200 ROOMS WITH BATH. 475 ROOMS AT $4 AND $5.

The Book-Cadillac

DETROIT

Finest in Appointments and Service No Higher in Price

Convention facilities are most exceptional. Three immense public rooms on one floor will comfortably seat an attendance of 2,500. Smaller conference rooms also available.

Guest rooms begin on the seventh floor, giving unusual freedom from traffic noise. All rooms have outside exposure, private bath, and circulating ice water. Six express elevators give rapid access to the twenty-nine floors.

Dinner Dance in Blue Room nightly, except Sundays, from 7 p.m. to 1 a.m. Dinner de Luxe each evening (except Sunday) in Blue Room and English Grill, $2.25.

To S. A. E. Members:-

The Book-Cadillac is headquarters for the automotive fraternity in Detroit. You are invited to make free use of the hotel's conference rooms and facilities at all times.

Your stay at Book-Cadillac is further made enjoyable by a wide variety of restaurants serving substantial food at moderate cost.

There's a new pastry shop and tea room, too. All that it sells, even the candy, is prepared by Book-Cadillac chefs in our kitchens.

THE BOOK-CADILLAC HOTEL COMPANY - DETROIT

ROY CARRUTHERS, *President*

WASHINGTON BOULEVARD AT MICHIGAN AVENUE

TIJUANA MEXICO CORONADO BALBOA PARK CITY POINT LOMA GROSSMONT OLD MISSION
Personally Conducted Tours
Parlor Chair Cars
DE LUXE
U.S. GRANT HOTEL
MAIN 25

STAGE-COACH EQUIPPED WITH FIRESTONE GUM-DIPPED PNEUMATIC TIRES

In Step with Engineering Progress

An important feature of the Firestone program of co-operation with the automotive industry is the comprehensive service placed at the disposal of motorbus engineers.

At their command is an experienced personnel and the wide Firestone resources, backed by every equipment for thorough research and testing—in laboratory and road work.

The Gum-Dipped Truck and Bus Pneumatic, for example, furnishes impressive proof of what Firestone tires can do to make design and building more effective—to increase the quality of motor-bus performance and lower operating cost.

The Firestone Line includes tires which, on any type of vehicle—motorbus, truck or passenger car—can be depended on to advance still higher the standard of highway transportation.

MOST MILES PER DOLLAR

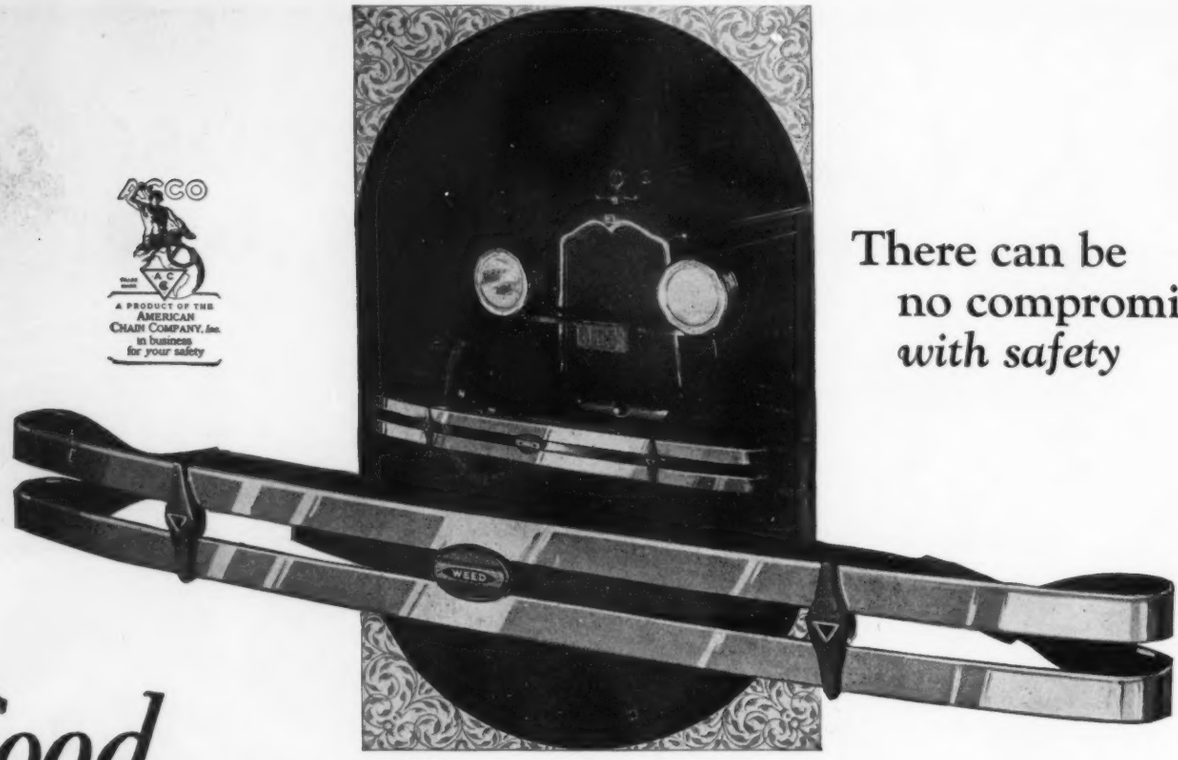
The Mark of Quality

Firestone

TRUCK AND BUS PNEUMATICS

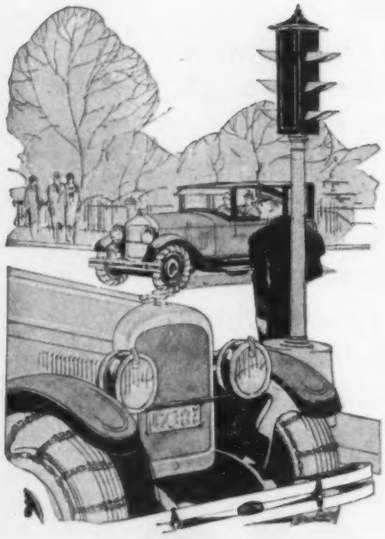
AMERICANS SHOULD PRODUCE THEIR OWN RUBBER . . Harvey S. Firestone

ACCO
A PRODUCT OF THE AMERICAN CHAIN COMPANY, Inc. in business for your safety



There can be no compromise *with safety*

Good Bumpers enhance the car's appearance



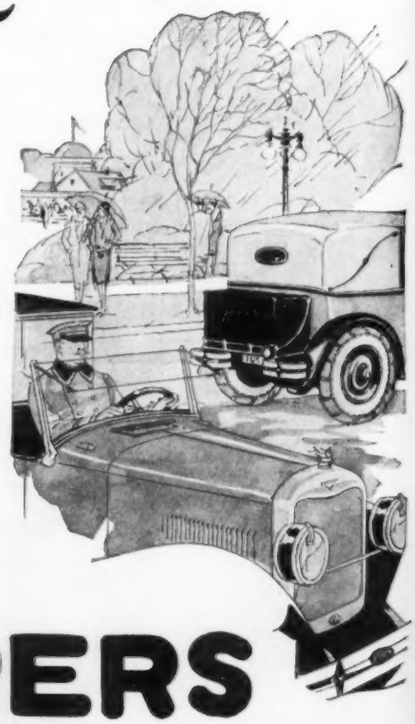
Beauty of line and design in WEED Bumpers adds immeasurable smartness to any car. To beautify is one WEED Bumper duty.

Resilient WEED spring bars, designed to resist impact at all *points* of impact, offer maximum protection per pound of steel. To protect and absorb impacts is the other duty.

The graceful curve of WEED Bumpers is not only pleasing to the eye, but avoids hooking in traffic. Even the front clamps are molded to glance off, rather than catch onto objects of impact.

Write for literature showing the types of WEED Bumpers best suited for your product. You will want to recommend them.

AMERICAN CHAIN COMPANY, *Inc.*
BRIDGEPORT, CONNECTICUT
IN CANADA
Dominion Chain Co., *Limited*, Niagara Falls, Ontario
DISTRICT SALES OFFICES: Boston, Chicago, New York, Philadelphia, Pittsburgh, San Francisco
World's Largest Manufacturers of Welded and Weldless Chains for All Purposes



WEED BUMPERS

Designed to appeal to sensible drivers

For Every Purpose Ferry Process Screws

Type, Basic

Carbon	.08 —.12
Manganese	.30 —.45
Phosphorous	.025 Max.
Sulphur	.045 Max.

Tensile strength 60,000 lbs. to sq. inch. minimum.

Furnished heat-treated, bright finish. Used for all ordinary purposes.

Type 2737

Carbon	.27 —.37
Manganese	.70 —.90
Phosphorous	.04 Max.
Sulphur	.045 Max.

Tensile strength 110,000 lbs. to sq. inch. minimum.

Furnished double heat-treated, black finish. While extra tensile strength is secured this steel can not be recommended as uniform in quality, owing to the high carbon content, as the other types mentioned.
Used where extra strength is desired.

Type 2330—Nickel steel

Carbon	.25— .35
Manganese	.60— .80
Nickel	3.25—3.75
Phosphorous	.04 Max.
Sulphur	.045 Max.

Tensile strength 140,000 to 200,000 lbs. to sq. inch.

Furnished special heat-treated, to Brinell hardness desired, black finish. Used to perform severe duty.

Type 3135—Nickel steel

Carbon	.30— .40
Manganese	.50— .80
Nickel	1.00—1.50
Chronium	.45— .75
Phosphorous	.04 Max.
Sulphur	.045 Max.

Tensile strength 140,000 to 200,000 lbs. to sq. inch.

Furnished special heat-treated, to Brinell hardness desired, black finish. Used to perform severe duty.

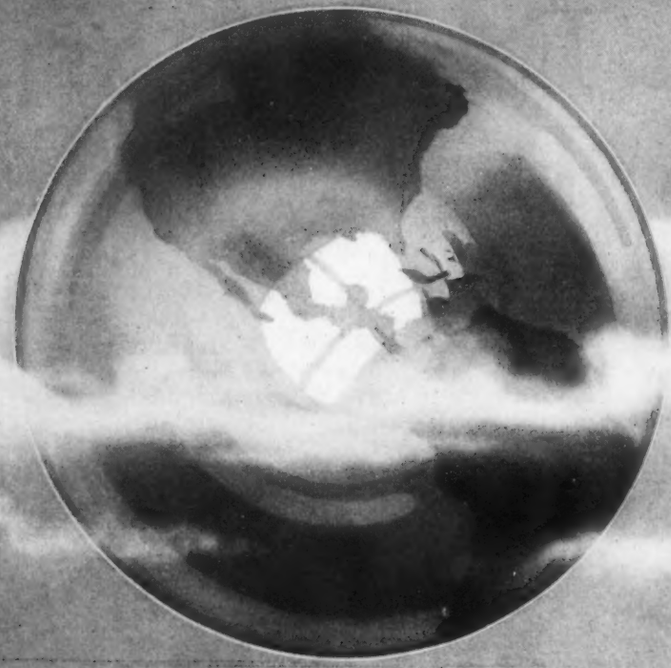
THE installation of our new and enlarged heat-treating department, working in conjunction with our metallurgical laboratory; offers our customers the latest improvements in methods to secure the maximum uniformity and strength from the Steels shown above.

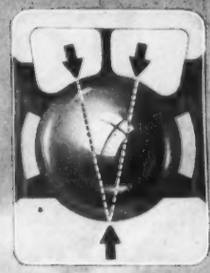
Our new building and equipment, designed and perfected by Thomas Ferry for heat-treating Ferry Process Screws, to the analysis above, guarantees our customers the greatest service from these steels. Our equipment through his personal supervision is peculiar to the Ferry Cap & Set Screw Company, only, and we offer you its advantages in solving your problems and helping you meet your requirements. Write to us.

"If it's upset—it must be heat-treated."

THE FERRY CAP & SET SCREW CO., CLEVELAND, OHIO

FERRY
PROCESS SCREWS



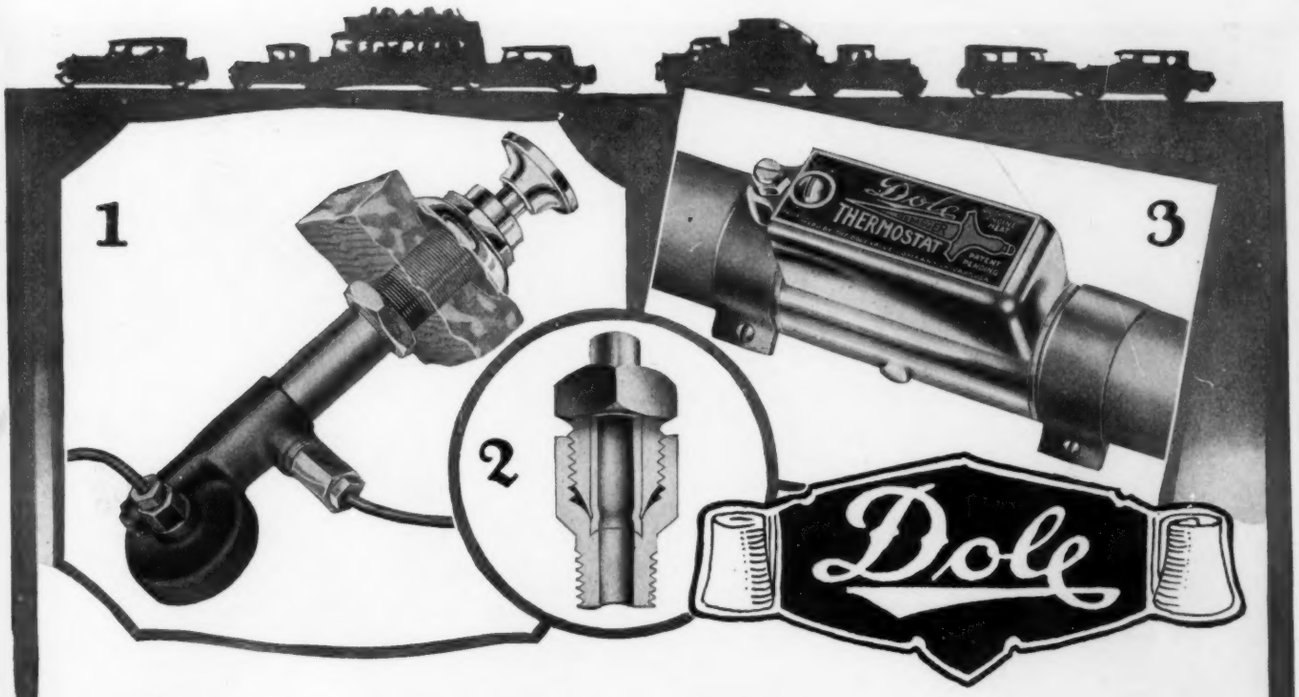


Adaptable the World over

Engineers the world over, recognize the 3-Contact design as the final solution of better bearing service. It means that Schatz "UNIVERSAL" Annular Ball Bearing easily sustains unusual stress, thrusts and loads which would incapacitate an ordinary bearing. "UNIVERSAL" design means much longer life and increased efficiency. These features give to this bearing leadership which is invariably accorded any article of superior merit.

THE FEDERAL BEARINGS CO., Inc., POUGHKEEPSIE, N. Y.

Schatz
"UNIVERSAL"
Registered U.S.Pat.Off.
Annular
BALL BEARING



Automotive Necessities

1 2 3

Dole Leakproof Primer

One or two strokes from the dash and your engine starts smoothly under the most unfavorable weather conditions. No sputtering, no strangling, no choking. A definite operation is performed with a single stroke of the Dole Primer, resulting in a small quantity of ***vaporized*** gas being injected into the intake manifold. Prevents crank case dilution and unnecessary drain on batteries, saves oil and reduces wear on bearings. Makes your motor start when you want it to start.

Dole Double Compression Coupling

Used as standard equipment on many well-known makes of cars —the perfect non-leakable, reconnectable joint for oil and gasoline lines. Absolutely insures against vibration and leakage. This fitting requires no soldering, no brazing, no flaring of the tubes, and no sleeves.

Note the double joint where the screw compresses the tube, and where the tube is swedged into the "V" slot. Used by many prominent manufacturers of automobiles, tractors, gas engines and accessories.

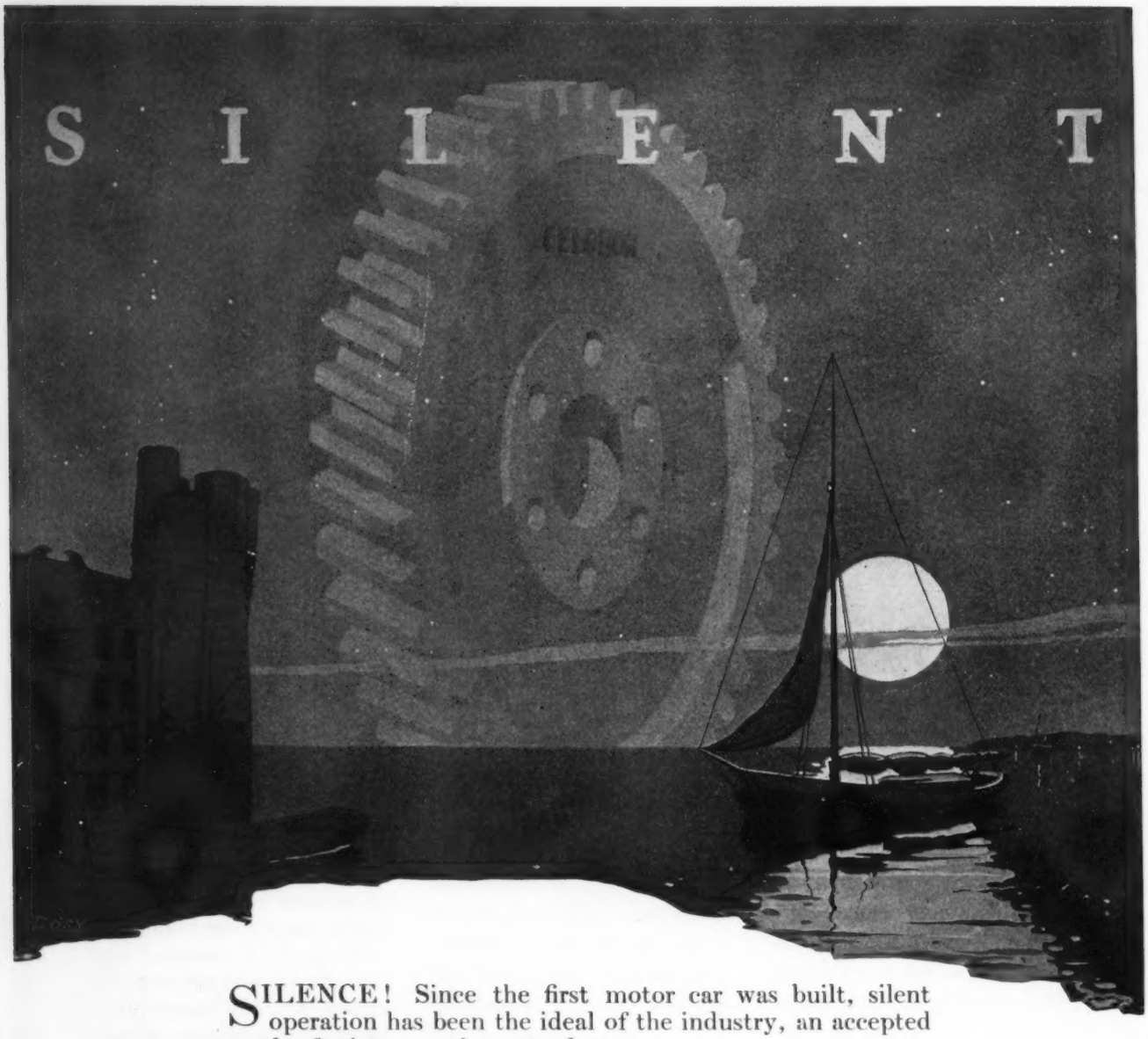
Dole Red Dagger Thermostat

Eliminates the use of all forms of radiator coverings. Raises engine temperature from 60° to 160° in three minutes. The butterfly valve is automatically closed at cold temperatures, preventing the passage of water until the engine reaches the most efficient running temperature. The quick and even warming of the engine results in better carburetion, increased mileage and the reduction of crank case dilution. The efficient temperature so quickly attained is maintained under all weather conditions, driving loads and varying speeds. Installed in 15 minutes —never requires adjustment.

Manufactured by

THE DOLE VALE CO.

1923-33 Carroll Ave.
CHICAGO



SILENCE! Since the first motor car was built, silent operation has been the ideal of the industry, an accepted mark of aristocracy in motordom.

The silence of Celoron Timing Gears endures through thousands, even hundreds of thousands of miles. It is this quality, above all others, which has won them the preference in cars already numbered by millions.

There are other millions of front ends which await the boon of silent, steady operation obtainable through the installation of Celoron Timing Gears.

Diamond State Fibre Company

BRIDGEPORT, PENNSYLVANIA — CHICAGO, ILLINOIS
PARIS, FRANCE — LONDON, ENGLAND
Diamond State Fibre Co. of Canada, Ltd., Toronto, Canada

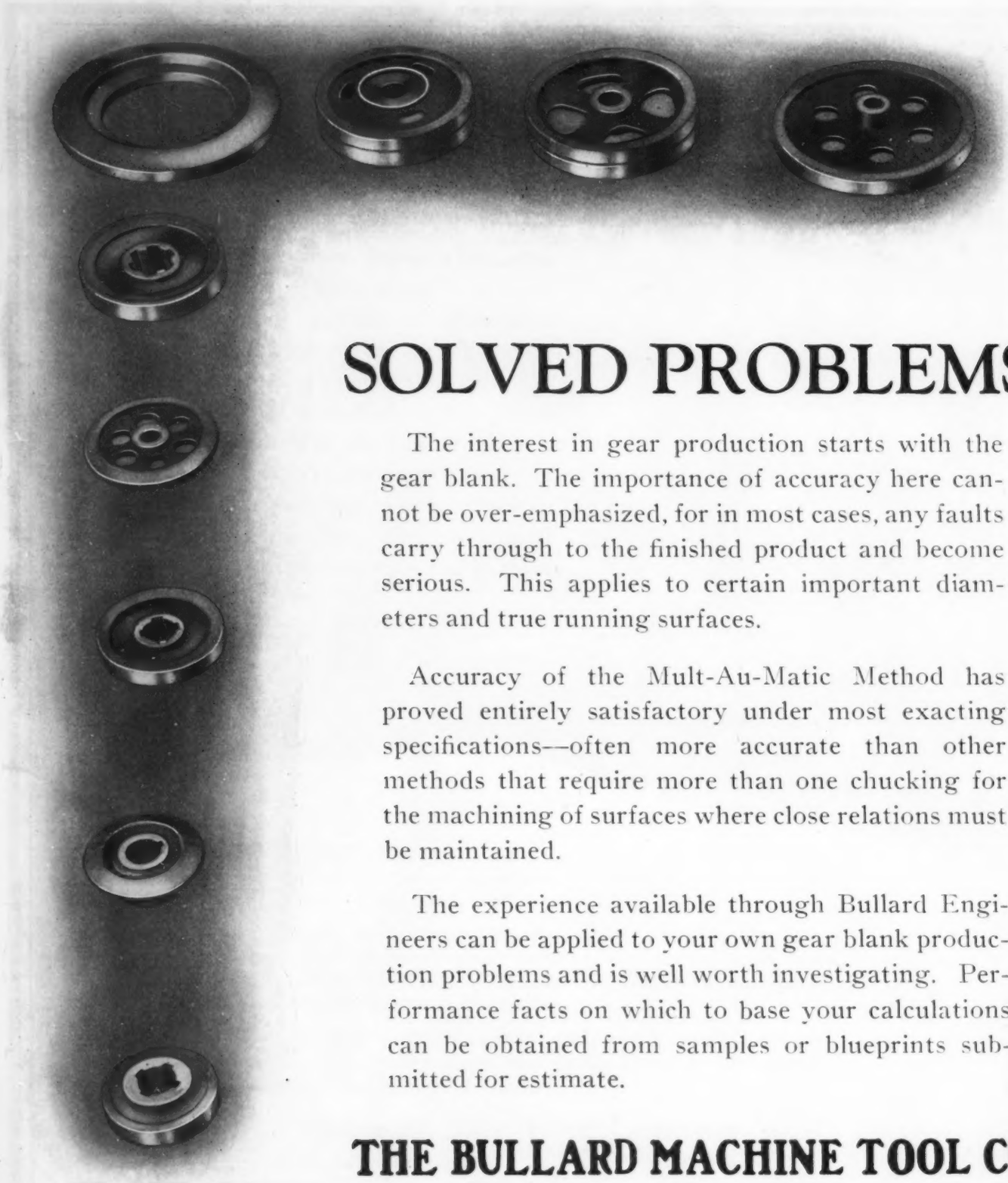
CELORON
TIMING GEARS

Another Consideration

Although the Belflex improvement represents the development of an original idea, the principle involves, primarily, a new use of an old and tried material, rubberized fabric. Cotton can be woven to possess the tensile strength of steel, and, for practical purposes has proven everlasting. One Belflex rubberized fabric shackle has actually held the weight of two complete automobiles. We suggest a consideration of such basic facts in connection with the more obvious advantages of our improvement.

BELFLEX CORPORATION
366 Madison Avenue New York City

BELFLEX



SOLVED PROBLEMS

The interest in gear production starts with the gear blank. The importance of accuracy here cannot be over-emphasized, for in most cases, any faults carry through to the finished product and become serious. This applies to certain important diameters and true running surfaces.

Accuracy of the Mult-Au-Matic Method has proved entirely satisfactory under most exacting specifications—often more accurate than other methods that require more than one chucking for the machining of surfaces where close relations must be maintained.

The experience available through Bullard Engineers can be applied to your own gear blank production problems and is well worth investigating. Performance facts on which to base your calculations can be obtained from samples or blueprints submitted for estimate.

THE BULLARD MACHINE TOOL CO.

BULLARD

MULT-AU-MATIC

IN GEAR BLANKS

Rate of production is, of course, important. Transmission gears faced, bored and broached are mounted on mandrels and machined in thirty to forty seconds apiece. Change of set-up from one piece to another is made in from two and one-quarter to four and three-quarter hours. Ring gears chucked twice on a double index Mult-Au-Matic are machined all over in sixty-two seconds to ninety seconds for the common range of sizes. Timing gears are produced in thirty-eight to sixty-five seconds each. Bevel gears of various types include a wider range of time.

But cost per piece! That tells the story—and the savings over other methods! Whether you have steady runs, or a few hundred of each blank with frequent change of set-up or perhaps only sufficient volume for part time operation. A Mult-Au-Matic estimate will give you some interesting data to figure with.

BRIDGEPORT, CONNECTICUT, U.S.A.

BULLARD

MULT-AU-MATIC

The expert care of a private chauffeur

—to help your cars give better service

After all, there's only one way to know when a car is lubricated properly. Go over *every* bearing part and *see that it receives* lubricant.

When your cars are equipped with Alemite, or Alemite-Zerk, lubrication is a simple, easy job for the motorist. He can go over his car in a few minutes with the hand compressor—every 500 miles. Or he can turn the job over to his nearest Alemite Lubricating Service Station.

Over 72,000 men are employed in these stations. Every 24 hours 80,000 cars are given the same expert lubricating care they would receive from a private chauffeur.

In less than three years the public demand for Alemite Service has more than tripled the number of stations. There are now over 36,000 officially recognized. Probably twice as many others. Your car owners cannot drive far in any direction without seeing the familiar sign, "Alemite Lubrication—Drive in."

That is one reason why the Alemite systems insure regular methodical lubrication that makes your cars give better service.

THE BASSICK MFG. CO.
2654 N. Crawford Avenue
Chicago, Illinois

ALEMITE

Products of The BASSICK MANUFACTURING COMPANY

ALEMITE ZERK

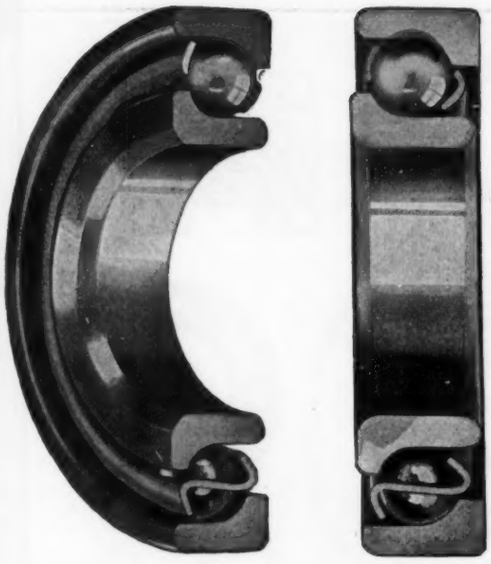
Service for cars with either system at any Alemite Station

Alemite and Alemite-Zerk are equally adaptable for Industrial Machinery

ALEMITE

High Pressure Lubrication

Reg. U. S. Pat. Off.



Angular Contact Radial Bearings

Angular Contact Thrust Bearings

Services of our Engineering Department are at your command at all times on lay-outs where Angular Contact Radial Bearings or Angular Contact Thrust Bearings may be used.

We also manufacture Thrust Ball Bearings to your blue print requirements.

Our Experience is broad and covers many years. When may we be of service to your organization?

These Bearings furnished to your requirements.

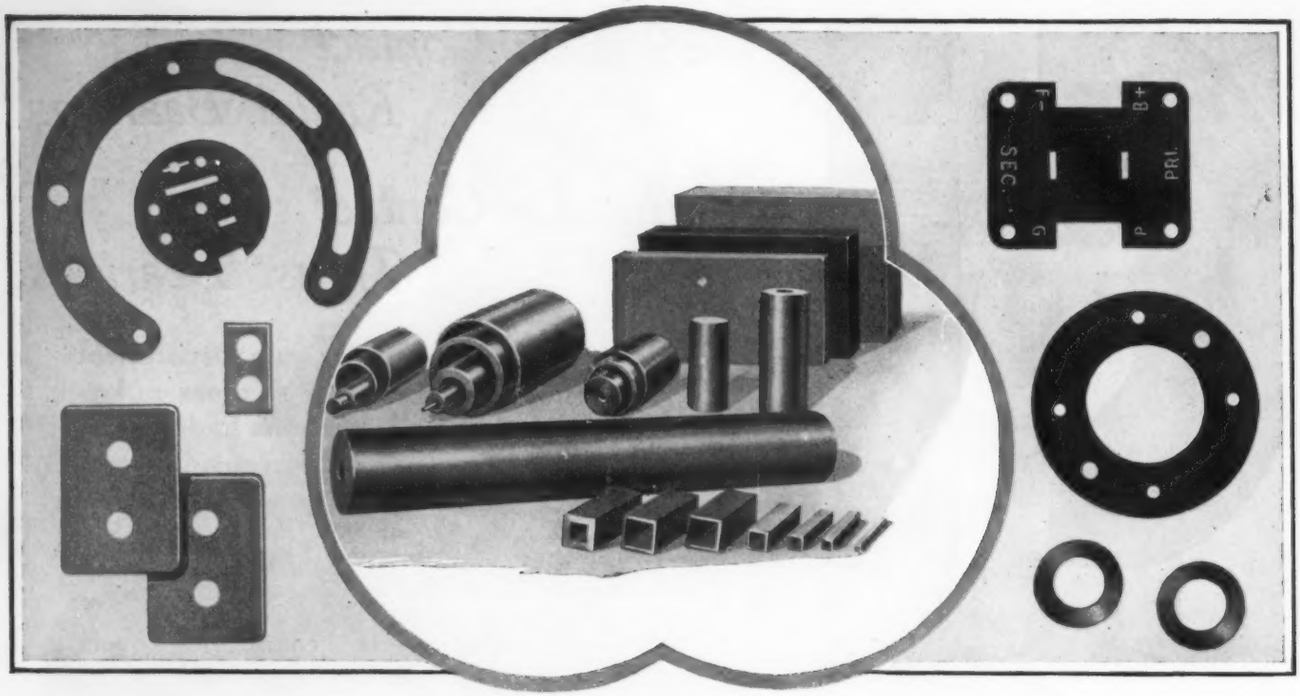
Send us your blue-prints and inquiries.

The

BEARINGS COMPANY of AMERICA

LANCASTER, PENNA.

DETROIT OFFICE—1012 FORD BLDG.



Bakelite Laminated provides permanent insulation

For continuously satisfactory performance the electrical system of a car requires insulation that will not dry out nor puncture and is immune to injury through contact with oil, water or gasoline.

Because Bakelite laminated meets every requirement you will find it used throughout the electrical systems of motor cars, and on electrical accessories of every kind. A partial list of these applications follows:

Switch backs of ignition systems, bushings, washers, punchings on breaker assembly and starting motor, generator, relays, horns, lamps, cigar lighters, generator and magneto drives, spotlight switches, steering column switches, cable conduits, fan washers, coil cases, battery switches, brush holder rings.

We offer the services of our engineers and research laboratories in adapting Bakelite to other automotive needs.

Write for Booklet 5

BAKELITE CORPORATION

247 Park Ave., New York, N. Y. Chicago Office, 636 W. 22nd St.

BAKELITE CORPORATION OF CANADA, LTD., 163 Dufferin St., Toronto, Ont.

BAKELITE

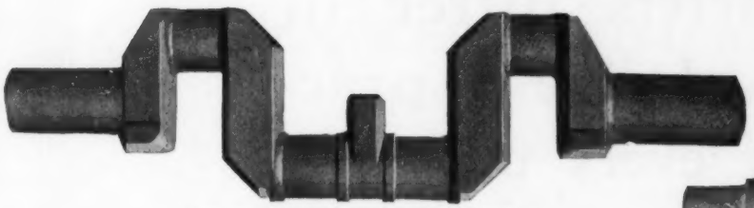
REGISTERED U. S. PAT. OFF.

THE MATERIAL OF A THOUSAND USES

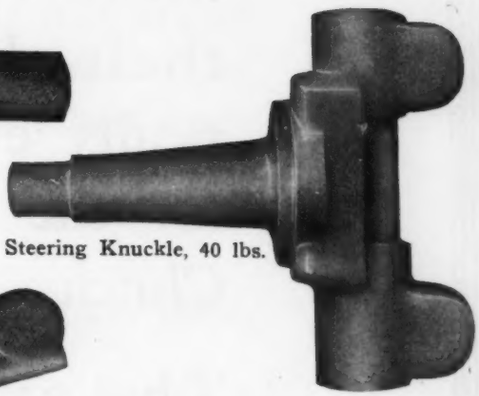
"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

Drop Forgings

Front Truck Axle, I Beam Section, 180 lbs.



Truck Engine Crankshaft, 100 lbs.



Steering Knuckle, 40 lbs.

Connecting Rod, 5½ lbs.

Any Type—Any Size up to 300 lbs.

Exceptional equipment to meet your requirements for drop-forged parts—anything up to 300 lbs.—any analysis steel. Heat treating equipment.

Our plant's capacity of 2300 tons a month, and its location convenient to its sources of raw materials facilitate prompt deliveries.

Behind our ability to satisfy you is 44 years' experience, a complete metallurgical laboratory, and a highly skilled engineering staff—all at your disposal without obligation.

Send Us Blueprints for Estimate

Union Switch & Signal Co.

Drop Forge Division

Pittsburgh Division Swissvale, Pa.

Motorists differ in their choice of practically every unit part for the car *except the Clutch.*

The experience of millions of seasoned drivers has identified superior clutch performance with clutches *made only by . . .*

The
Borg & Beck Company

310 So. Michigan Ave.
Chicago

The Open Car

DISCRIMINATING buyers of open cars today demand the same sort of refinements and niceties as are found in present day closed cars.

Your open car demands the best.

The Flush Type Curtain Fastener has no equal for neat appearance, easy operation, durability and utility.

They are popular with car owners.

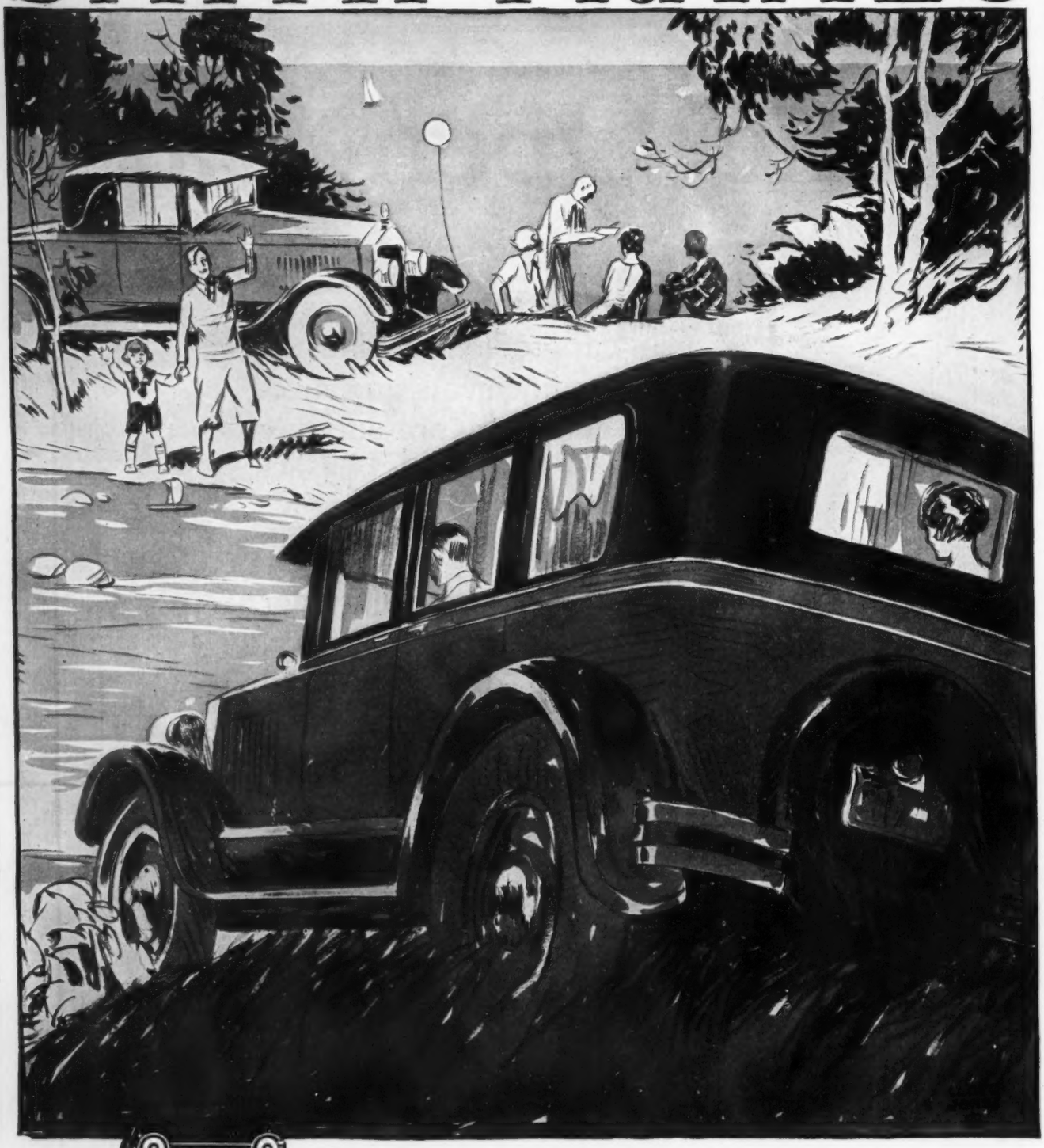
That is why more and more builders of fine motor cars are using them.

Cinch Manufacturing Corporation

2335-2347 W. Van Buren St.

CHICAGO

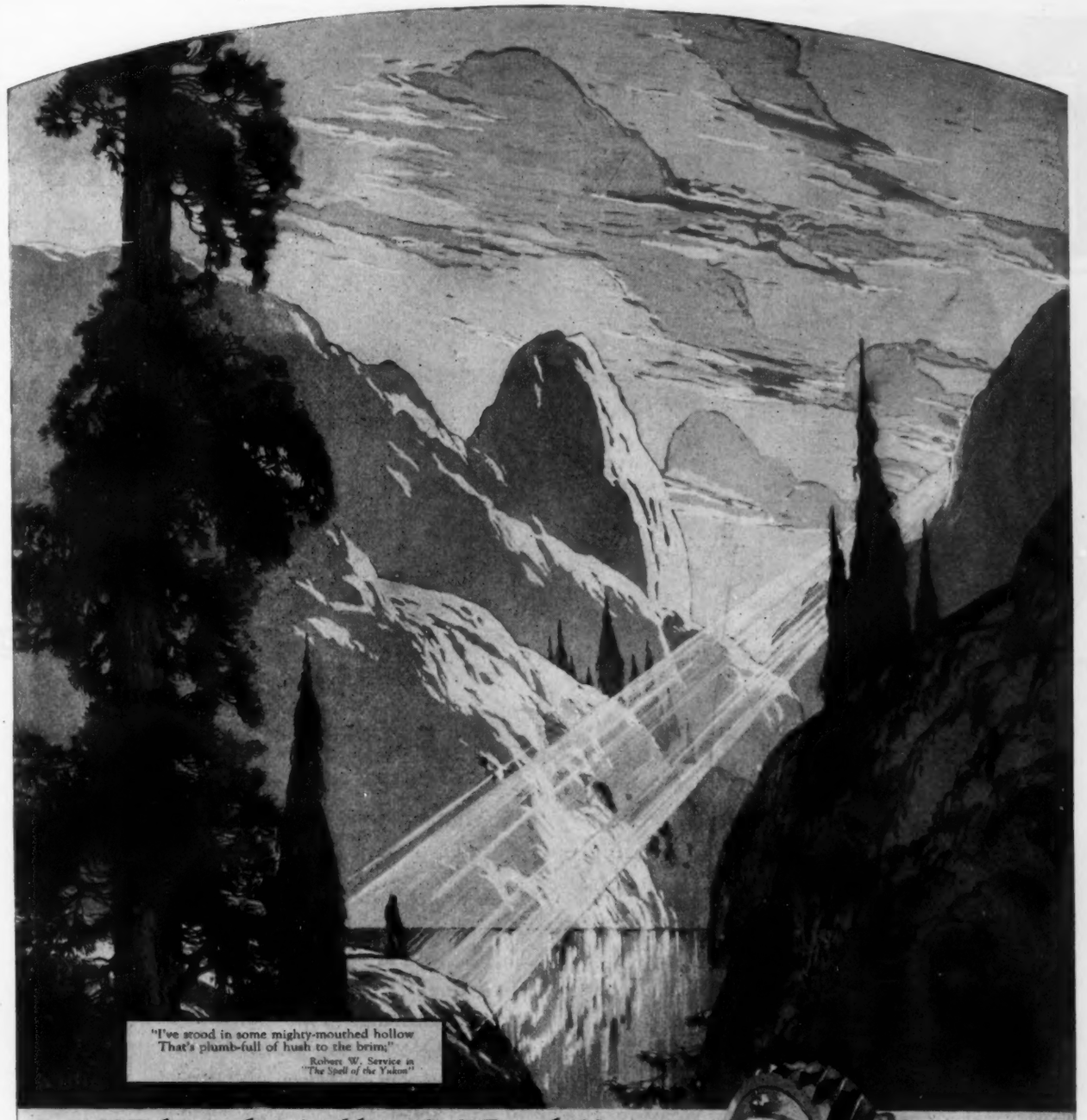
SMITH FRAMES



Smith
MILWAUKEE

MOTOR CARS today ***are*** *more beautiful; yet subjected to continually harder service. Their longer life in the face of these conditions may be a mystery to some—but not to the men who appreciate the progress made in frame design.*

A. O. SMITH CORPORATION · MILWAUKEE, WISCONSIN
DETROIT OFFICE: GENERAL MOTORS BLDG.

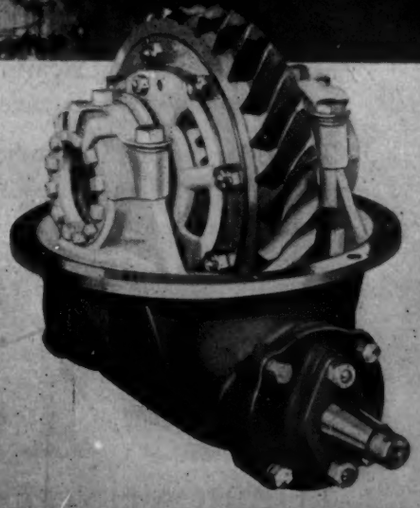


"Plumb-full of Hush"

ABSOLUTE NOISELESSNESS in the rear axle is one of the urgent demands upon the Automotive Industry today—Quietness for the sake of quietness as well as an indication of the absence of friction and wear.

Quietness bespeaks smoothness, simplicity, dependability, maintained efficiency, continuity of operation and long life.

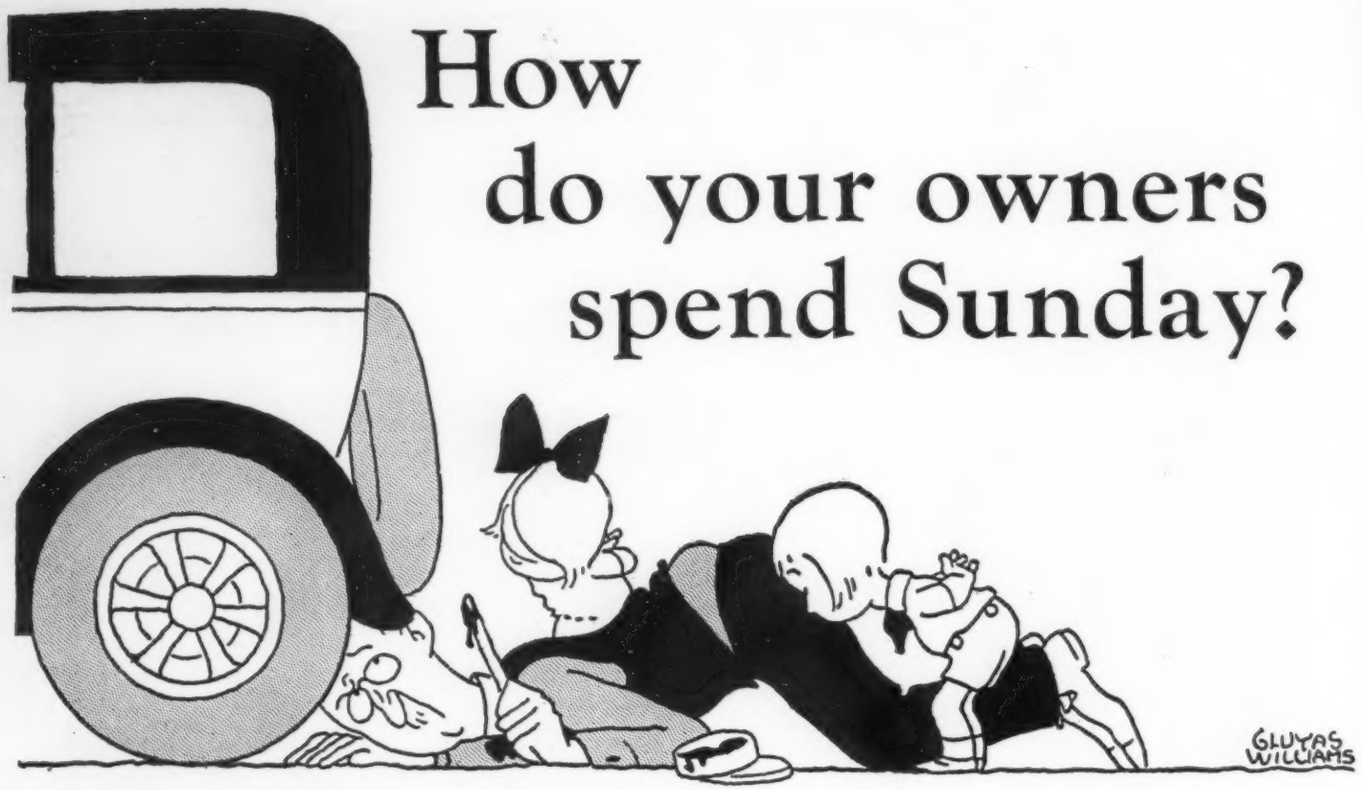
Cleveland Worms and Gears are *"Plumb-full of hush"*.



THE CLEVELAND WORM & GEAR COMPANY

East 80th Street ,, *"America's Pioneers in Worm Gearing"* ,, Cleveland, Ohio

How do your owners spend Sunday?



Under their cars or in them?

OWNERS are tired of spot-by-spot chassis greasing—they want relief.

They dislike the drudgery of hunting out each grease nipple and doping it by hand—they want something simpler.

Why not give them Bijur Lubrication—the simple, positive reliable system of lubricating the entire chassis in a moment's time?

The Bijur System is simplicity itself. Drip Plugs—one at each oiling point—are connected by the simplest possible piping to an oil reservoir and gun on the dash.

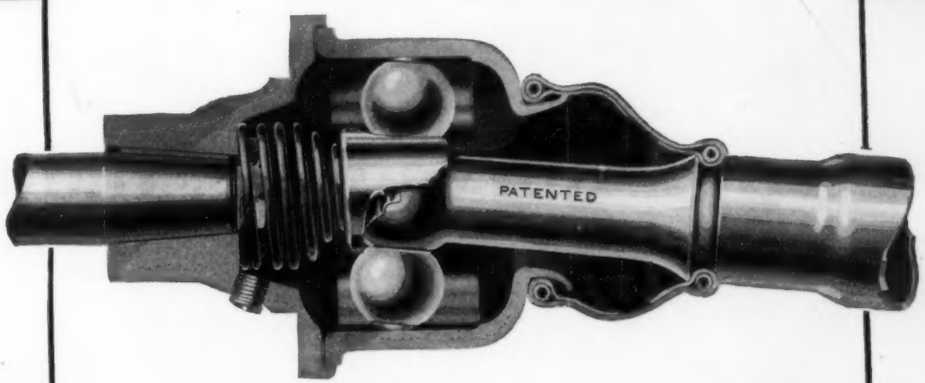
One pull of the gun handle puts the oil line under pressure and the Drip Plugs deposit a measured quantity of oil in the center of each bearing. That's all there is to it. No moving parts. Nothing to get out of order. Nothing to wear out.

Without obligation to you our Engineering Staff will gladly assist in redesigning chassis parts to accommodate the Bijur System.

BIJUR

LUBRICATING CORPORATION, NEW YORK

Originators of Instant Chassis Lubrication



EFFICIENT

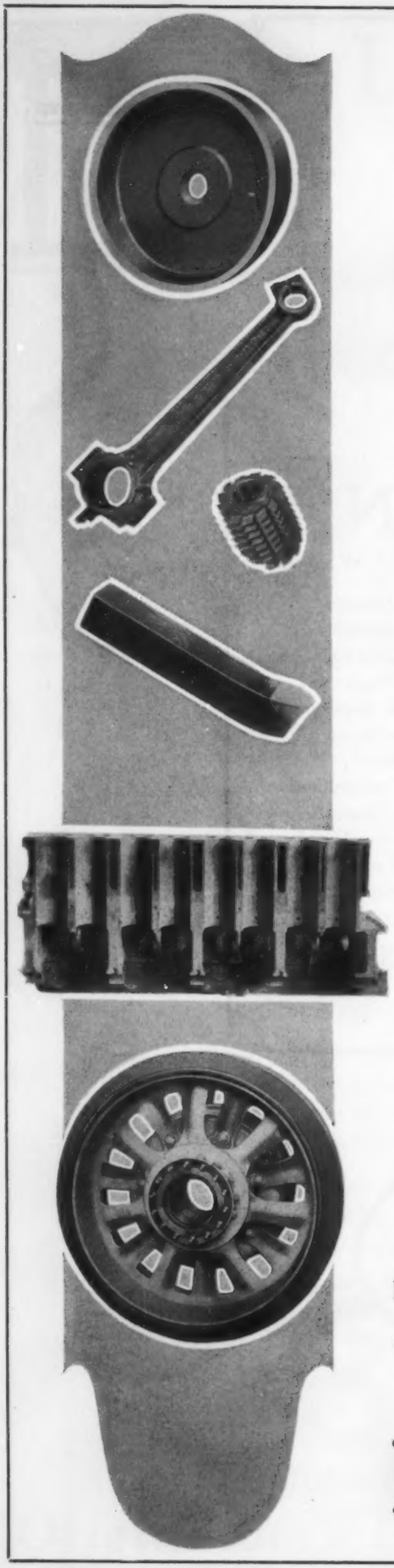
TRANSMISSION OF POWER

Simplicity of Design	Accessibility—Light Weight
Rolling Ball Contacts	Friction Greatly Minimized
No Sliding Spline Used	Freedom From Noise and Backlash
No Grease Packing Washers	No Eventual Loss of Lubricant
Centrifugal Force Retains Grease	Infrequent Attention Required
One-Piece Shaft Used	Smooth at High Speeds
Shaft Ends Piloted	Runs True Permanently
End Motion Thru Rolling of Balls	Resistance Reduced Tremendously
Scientific Heat Treatments	Long Life and Great Strength
Manufactured With Precision	Every Assembly Torsion Tested
Nine Years—One Product	Receives Undivided Attention
Made by Specialists	Correct Equipment for Every Part

UNIVERSAL PRODUCTS CO.
DETROIT, MICHIGAN

REGISTERED U. S. PATENT OFFICE

PARTIAL LIST OF USERS FOR YEARS
CHRYSLER
HUPMOBILE
AUBURN
GRAHAM BROTHERS



Bethlehem Products *for the* Automotive Industry

Alloy Steels—*for Every Purpose*

Tool Steels—*for Every Purpose*

Brake Drums

Rim Sections

Rolled Steel Truck Wheels

Mayari Pig Iron

Drop Forgings

Rolled Steel Fly Wheels

Ample manufacturing facilities; an experienced steel-making organization; control over raw materials; and a large inspection department trained to watch the minute details of manufacture essential to fine quality; make it possible for us to render complete service.

BETHLEHEM STEEL CO., *General Offices:* BETHLEHEM, PA.

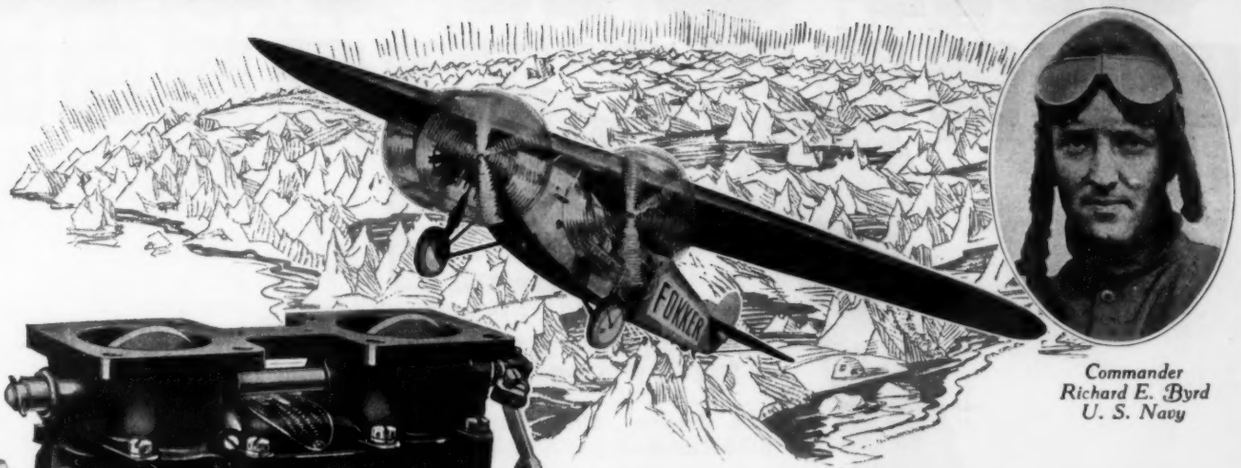
District Offices in the following cities:

New York Boston Philadelphia Baltimore Washington Atlanta
Buffalo Pittsburgh Cincinnati Cleveland Detroit Chicago
St. Louis Seattle San Francisco Los Angeles

BETHLEHEM STEEL EXPORT CORPORATION, 25 BROADWAY, NEW YORK CITY
Sole Exporter of our Commercial Products.

BETHLEHEM

Circles NORTH POLE!



Commander Richard E. Byrd U. S. Navy

Stromberg Air-Craft Carburetor Model NA-U5G

Supreme Test Proves Perfect Performance OF STROMBERG Carburetor

1560 Miles in Zero Temperature in 15 Hrs. and 51 Mins.

Commander Byrd made his epoch making flight to the North Pole and return May 9th, in the face of innumerable obstacles and hardships. One of the big reasons for the success of his gigantic undertaking, which was made without a hitch, was the *perfect performance of the Stromberg Carburetors* with which his three Wright Whirlwind Air-Cooled engines were equipped. These were the Stromberg Carburetors Air Craft Models NA-U5G.

This is just another record breaking feat which proves conclusively the ability of Stromberg Special Carburetors to perform perfectly under all conditions.

SUPREME ON LAND, AIR AND WATER

Stromberg Super Shock Absorbers

Give greatest comfort because they regulate spring action to the correct degree. For balloon or standard tires. Working parts protected against dirt, water and oil. Steel cable will not rust, stretch or break. No adjustment; no oiling or greasing. Made to measure for each make of car. Your trade will want them once they know them.

Stromberg Electric Windshield Wiper

Your customers cannot know the satisfaction and feeling of safety while driving in rain, fog, sleet or snow until they have one of these perfect vision wipers on their cars. Two speeds. Adjustable pressure on glass. Economical on battery current. Operates perfectly under all driving conditions. Dependable always.

Don't fail to get your share of the profits on these popular auto necessities

STROMBERG MOTOR DEVICES CO., 58-68 East 25th Street, CHICAGO

Direct Factory Branches NEW YORK 517 W. 59th St. BOSTON 760 Commonwealth Av. DETROIT 84-86 Hancock Av., W. MINNEAPOLIS 1609 Hennepin Av. KANSAS CITY, MO. 1809 McGee St.

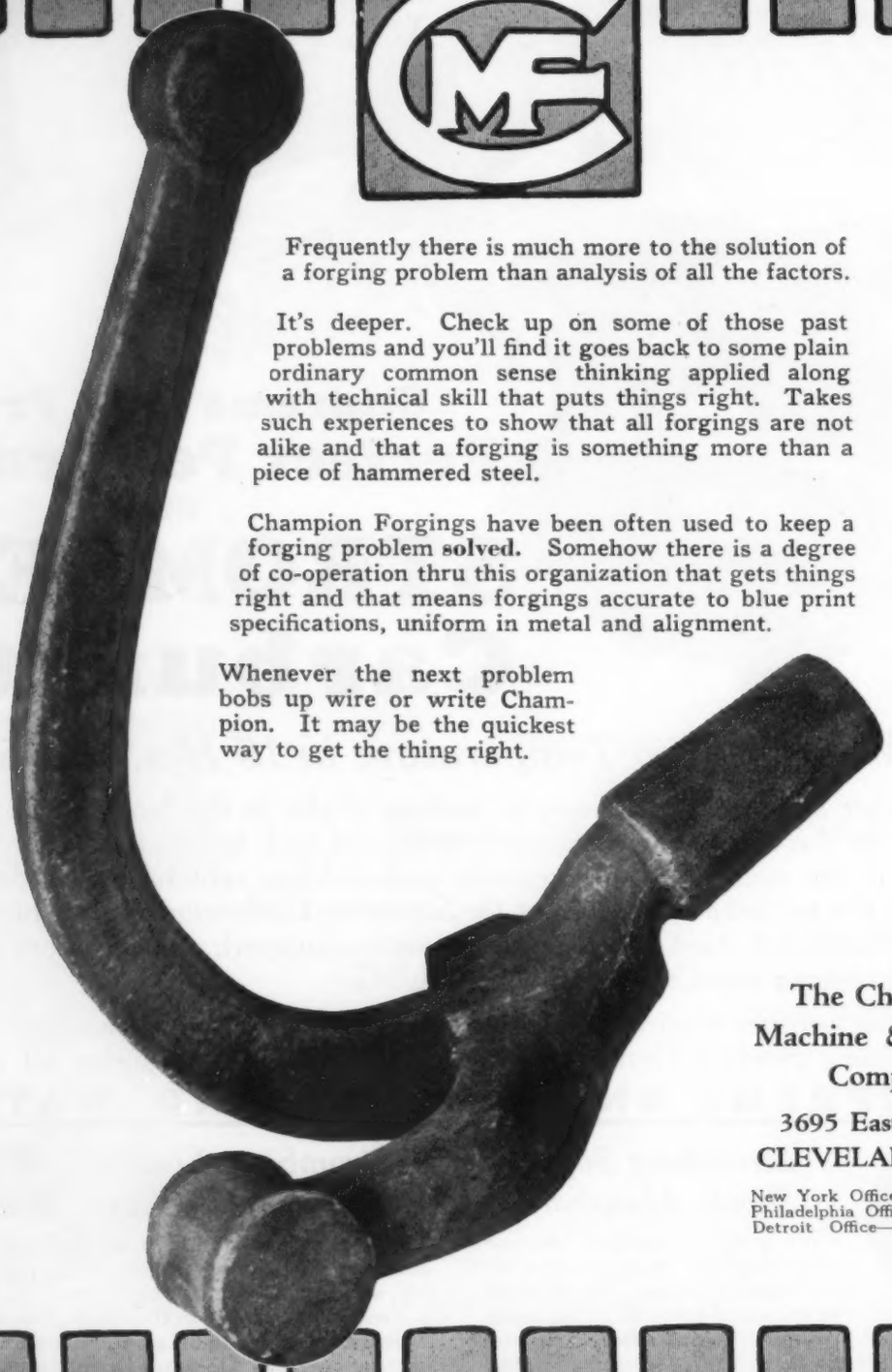
CHAMPION

Frequently there is much more to the solution of a forging problem than analysis of all the factors.

It's deeper. Check up on some of those past problems and you'll find it goes back to some plain ordinary common sense thinking applied along with technical skill that puts things right. Takes such experiences to show that all forgings are not alike and that a forging is something more than a piece of hammered steel.

Champion Forgings have been often used to keep a forging problem **solved.** Somehow there is a degree of co-operation thru this organization that gets things right and that means forgings accurate to blue print specifications, uniform in metal and alignment.

Whenever the next problem bobs up wire or write Champion. It may be the quickest way to get the thing right.



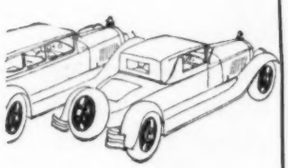
The Champion Machine & Forging Company

3695 East 78th St.
CLEVELAND, OHIO

New York Office—30 Church St.
Philadelphia Office—Bourse Bldg.
Detroit Office—705 Ford Bldg.

DROP FORGINGS

No motorist whispers words of praise as he tugs at a rusty rim

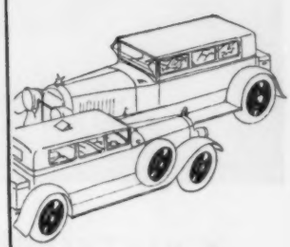


WHEN you see a motorist in the throes of tire-changing—tugging and wrenching in a blue haze—you know his car isn't on Budd-Michelin Wheels!

But it's a safe bet his next car *will* be. Changing a tire mounted on a Budd-Michelin Wheel requires less work and one hundred percent less wrath. There are no rim-clamps. No demountable rims.

A few turns on the cap nuts at the hub and the wheel can be slipped off, the spare wheel mounted, the cap nuts tightened and the job is done. Done in four minutes.

No wonder motorists are saying, "goodbye, buggy wheels!"



BUDD

WHEEL COMPANY

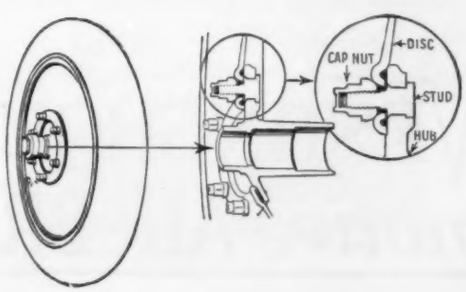
Detroit

Why BUDD-MICHELIN WHEELS *are* seen *but not* heard

. . . There can be no noise between disc and rim because they are permanently joined—practically one piece.

. . . The hub cannot cause noises because it is a one-piece forging.

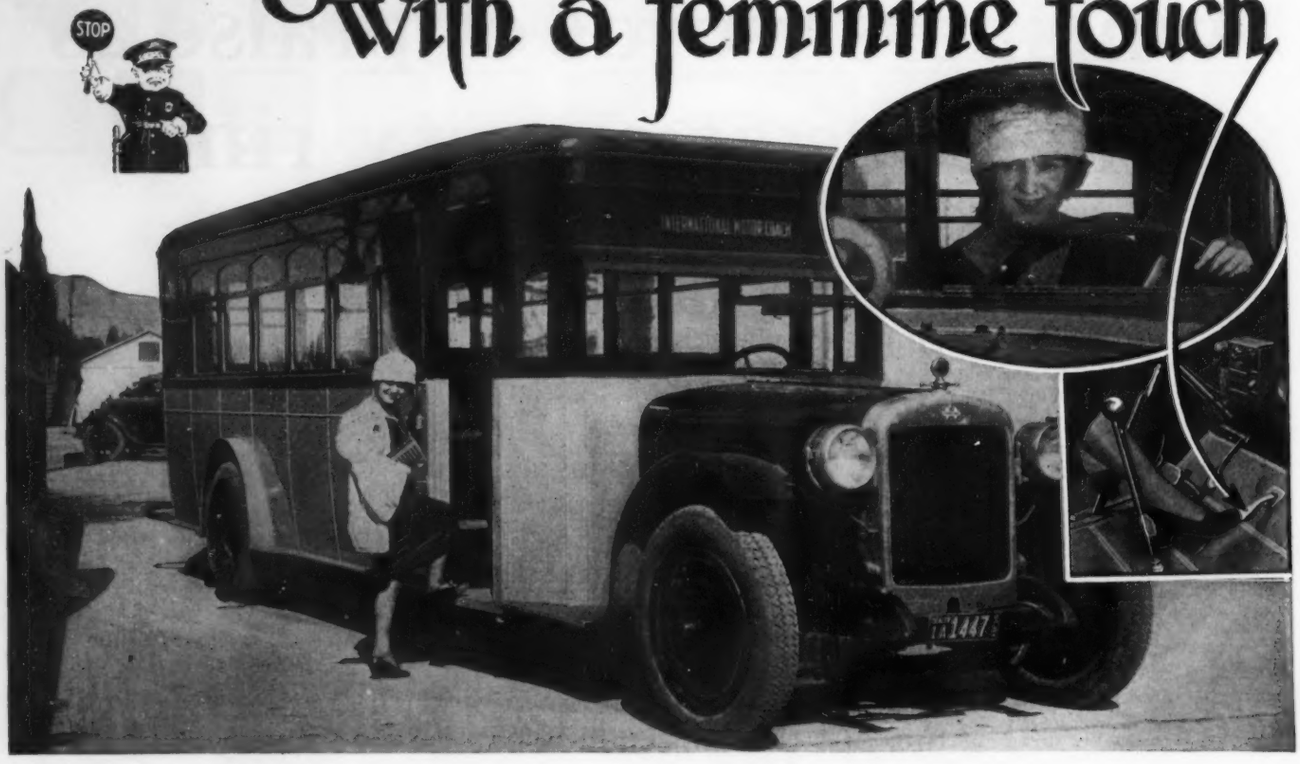
. . . The diagram shows how the mounting of the disc on the hub prevents any play or noise. The disc does not touch the studs—the cap nuts carry it.



Tightening the cap nuts brings disc and hub together with a tension like the compressing of a spring. Prevents any chance of noise here.

. . . The holes in the disc cannot be worn egg shape by the studs. The studs cannot be sheared off by the disc. The cap nuts cannot work loose because they are in effect self-locking.

Doing a man's size job with a feminine touch



CONTROLLING a modern bus is an extraordinary job with ordinary brakes. It taxes the physical strength and endurance of even a husky man.

Frequent and severe use of the foot brake may impose such a tiresome task upon the bus driver as to lessen operating safety or reduce traffic efficiency. If this handicap can be removed, the resulting driver comfort will become a valuable asset to insure greater security for the passenger and more passenger miles for the bus owner. The Westinghouse Automotive Air Brake is a power braking system which will adequately control even the heaviest bus without physical effort.

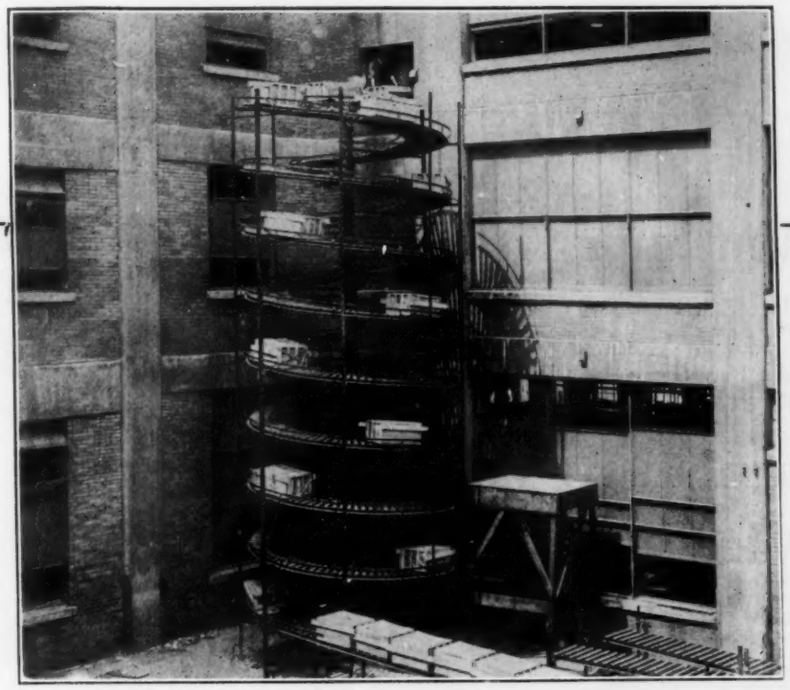
Even though your bus is not driven by a woman, the man's size job of stopping it can be accomplished by a mere "feminine" touch—a touch on the accelerator to go, a touch on the brake control pedal to stop—quickly, safely, smoothly.

WESTINGHOUSE AIR BRAKE CO.

AUTOMOTIVE DIVISION

General Offices and Works: WILMERDING, PA.

New York Washington Chicago St. Louis San Francisco Detroit



Starting Them Right

Where Responsibility Begins

Our responsibility to the trade begins with the shipment of the battery. To measure up to this responsibility, materials are bought on close specifications and carefully checked in our laboratories; complete production facilities with perfected mechanical methods have been provided; skilled workmen are employed; all workmanship and materials are subjected to rigid inspection.

Back of it all, born of a desire to please, is a definite purpose to render a valuable service to the car manufacturer, the dealer, the ultimate consumer.

Briefly, Westinghouse makes a quality battery; it can be bought wherever motor cars are used; capable service has been made available and the price is within the easy reach of all.

This is the last of a series of ads describing the methods and processes used in the manufacture of Westinghouse Storage Batteries—batteries that are making good for the car manufacturer, the service station, the car owner and for Westinghouse.

WESTINGHOUSE
BATTERIES

WESTINGHOUSE UNION BATTERY CO.
SWISSVALE, PA. U.S.A.

AUTOMOTIVE WIRE AND CABLE

Whatever the Standards Committees May Specify Graybar is prepared to furnish in Automobile Wire and Cable and general wiring supplies.

TOGGLE SWITCHES

GraybaR

ELECTRICAL SUPPLIES

Successor to *Western Electric* Supply Dept.

Offices in 55 Principal Cities. Executive Offices: 100 East 42nd Street, New York

Unretouched portrait of Threadwell Taps

"Finish" goes all the way through

No amount of gloss and high polish can ever fool an experienced mechanic. He knows there is more to a tap than appears on the surface.

All the skilled workmanship and scientific hardening and tempering which goes into the making of a Threadwell Tap would be useless if the material out of which that tap is made could not measure up to the requirements of the user.

That is why the inside, unseen "finish" is accurately tested before Threadwell workmen are allowed to use the steel of which Threadwell Taps are made. This material is a basic product that will reflect and extend the fine workmanship of Threadwell workmen. The "finish" of Threadwell Taps goes all the way through and comes out in the form of exceptional service on the hardest kind of tapping.

Let us tell you how and why Threadwell Service and Threadwell Taps are meeting a real need.

THE THREADWELL TOOL COMPANY
GREENFIELD, MASS.

1323 Dime Bank Building..Detroit, Mich.
135 St. Clair Ave., N. E...Cleveland, Ohio
809 Harrison Bldg.....Philadelphia, Pa.
Bessemer Building.....Pittsburgh, Pa.
1410 Porter St.....Richmond, Va.
396 Broadway.....New York City
604 Mission St.....San Francisco, Cal.
246 St. Paul St..... Rochester, N. Y.
230 South Penn St.....Indianapolis, Ind.

THE THREADWELL TOOL CO. THREAD WELL GREENFIELD-MASS-USA

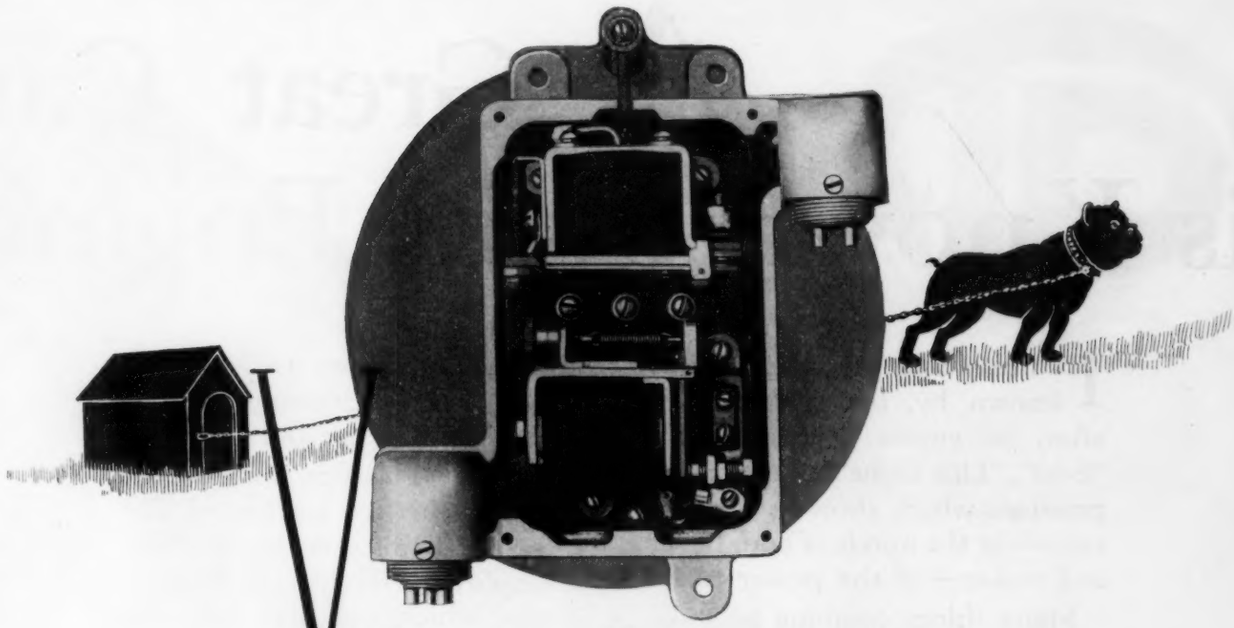
TAPS—DIES—SCREW PLATES AND SMALL TOOLS

LONG

PRODUCTS

Automotive
CLUTCHES
and
RADIATORS

THE LONG MANUFACTURING CO.
DETROIT, MICHIGAN



Voltage Regulation

the watch-dog of the electrical system

Get this straight—that most electrical troubles are *unnecessary*.

Voltage Regulation makes practically all serious electrical troubles unnecessary.

The Leece-Neville Voltage Regulated Electric System absolutely protects the battery against overcharging by an automatic method, which needs no attention whatever from the driver.

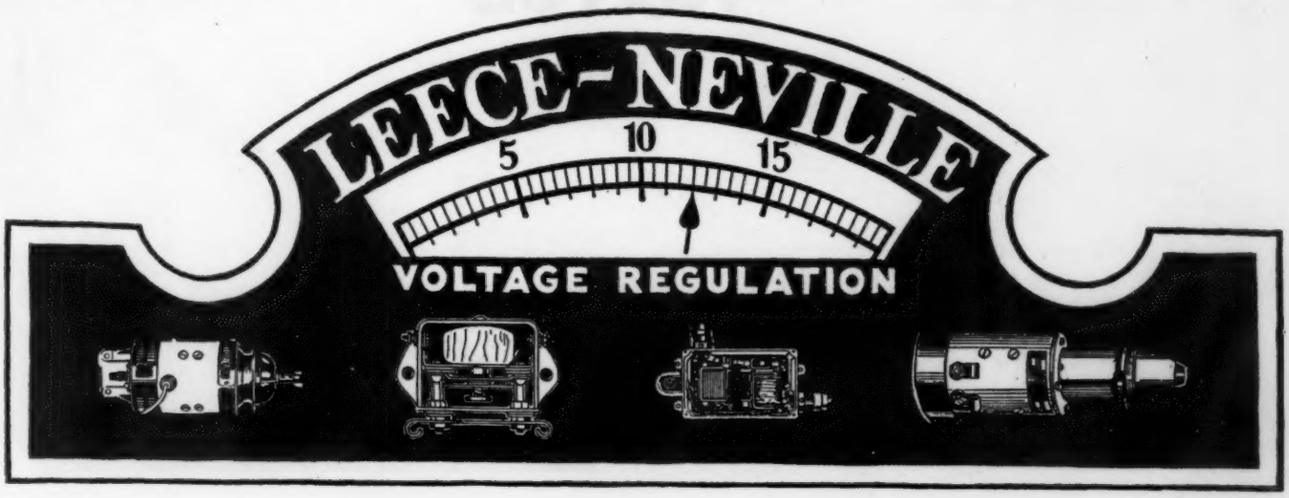
Burning out of light bulbs due to loose battery connections is unknown with Leece-Neville Voltage Regulation. In fact the battery can be removed entirely, and the truck run with all lights burning without any damage to lights or generator.

Leece-Neville Voltage Regulation has been thoroughly and completely demonstrated on trucks and buses.

Voltage Regulation Minimizes Electric Troubles

1. Battery cannot be overcharged.
2. The battery is charged only at the correct rate for its state of charge.
3. Battery will operate longer without requiring replenishing of electrolyte.
4. Life of battery greatly prolonged.
5. Lights can be operated direct from generator.
6. Loose connections will not cause lamp bulbs to burn out.
7. Makes most economical generator system.
8. Generator will not burn out if run with battery removed.
9. Lamp life greatly prolonged.
10. Motor coaches fitted with Leece-Neville voltage regulated generators provide passengers with satisfactory illumination and safe transportation.

THE LEECE-NEVILLE COMPANY, CLEVELAND, OHIO



A Great Car is Known by its Engine

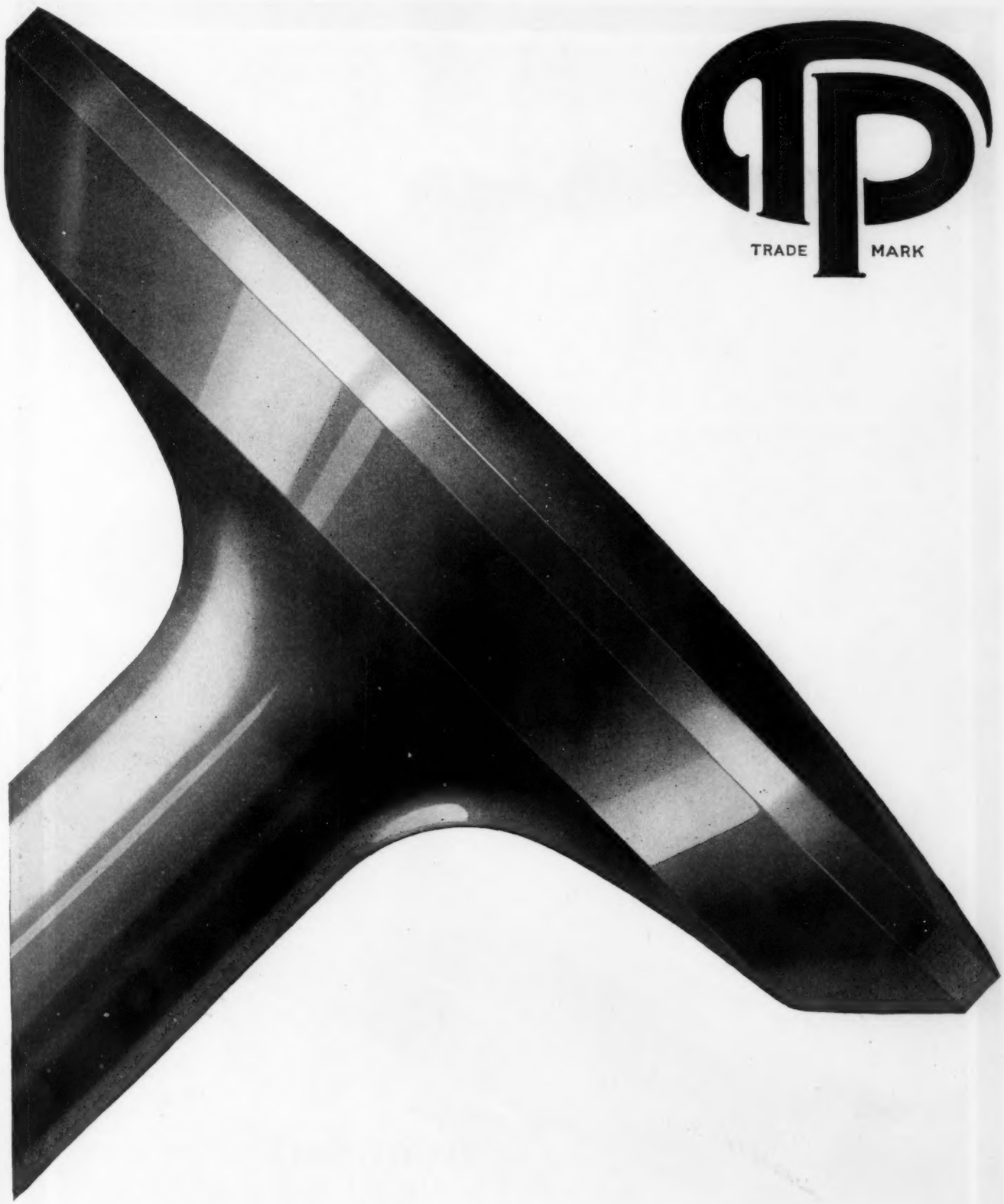
IN many cases the car is not only known by, but even *named* after, its engine. "Master Six", "8-80", "Line Eight" are typical expressions which show the importance—in the minds of both buyer and maker—of the power plant.

Many things combine to make that union of power, speed, flexibility and control which a great engine is. One thing—more than any other—is necessary to keep the combination functioning without interruption, or ups and downs in efficiency. That one thing is ***continuously perfect sealing of the valves.*** Is it not, then, worth while to employ the services of an organization which can give you the utmost procurable not only in basic valve quality, but also in advanced design and engineering cooperation?

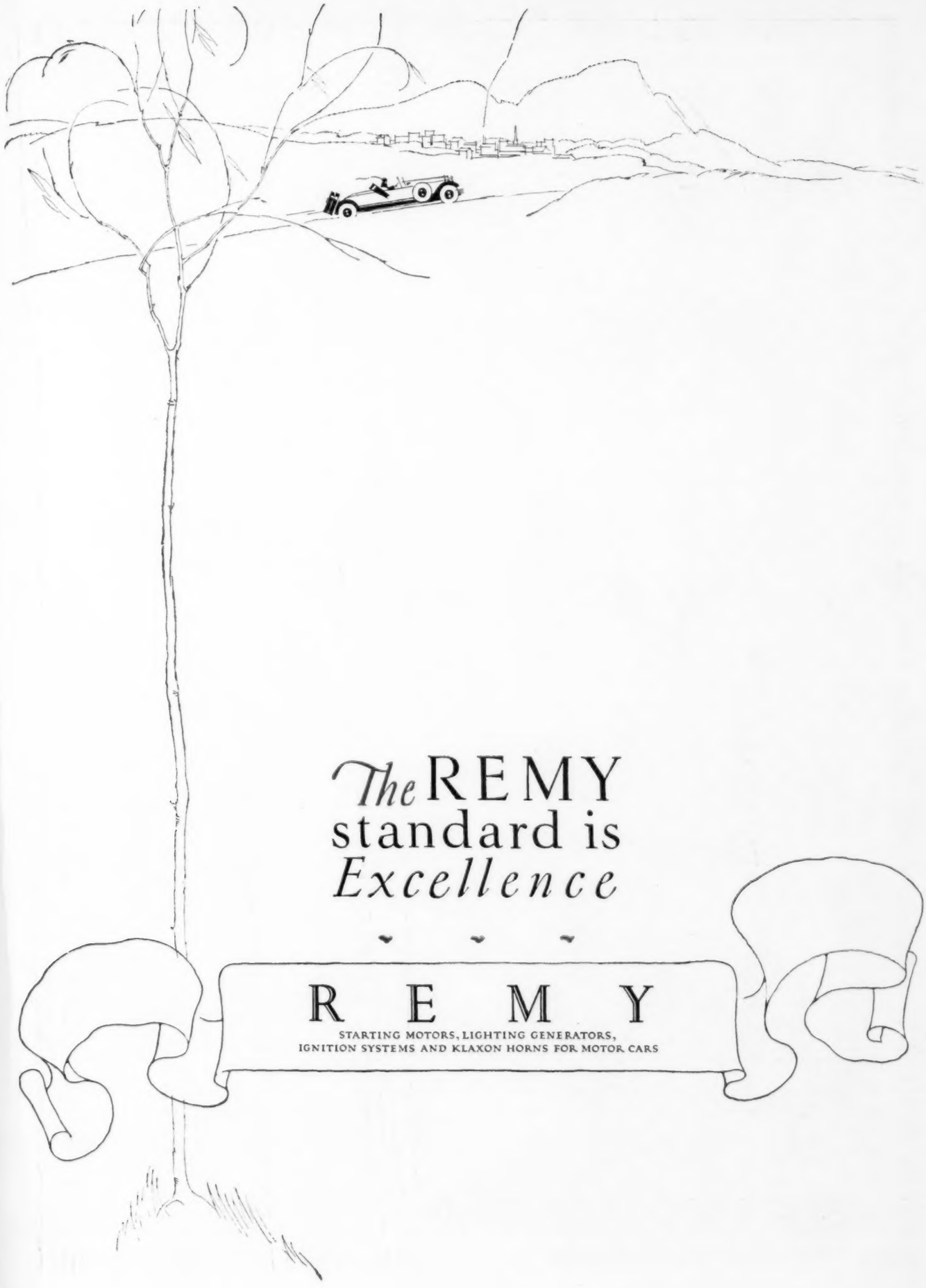
THOMPSON PRODUCTS, INC.
Manufacturers of Thompson Products
Thompson Valves, King, Shackle and Tie-Rod Bolts, Tappets, Drag Links, Tie Rods, Starting Cranks and Brake-Rod Assemblies.
Main Plant, CLEVELAND Michigan Plant, DETROIT

Thompson

Silcrome Valves


TRADE
MARK

BOLTS
EMPIRE
NUTS-RIVETS
You can ALWAYS depend on
EMPIRE BOLTS & NUTS
RUSSELL, BURDSALL & WARD
BOLT & NUT COMPANY
PORT CHESTER, N.Y.
Branch Office:
Straus Building
CHICAGO
Branch Office:
General Motors Bldg.
DETROIT
Branch
Factory:
ROCK FALLS, Ills.
Strimple & Gillette
160 Jackson Street
SEATTLE
Mandwell & Hartzell, Inc.
118-168 Eleventh Street
SAN FRANCISCO
Makers of Bolts, Nuts and Rivets Since 1845



The REMY
standard is
Excellence

REMY

STARTING MOTORS, LIGHTING GENERATORS,
IGNITION SYSTEMS AND KLAXON HORNS FOR MOTOR CARS

HASSLER

A Great Contribution

Hasslers give the Motorist the new and delightful sensation of ROAD RHYTHM

EVER since comfort became one of the prime considerations in the mind of the motorist, and long before the modern era of good roads and comfort-giving Balloon Tires, the Hassler Organization was confining itself to the development of devices to control the action of automobile springs, soften bumps and retard rebound.

Is it any wonder, then, that over two million motorists ride on the devices which bear the Hassler name?

—or that the Hassler Organization should be the first to produce an entirely new control-device, based on entirely new engineering principles and designed with the idea of overcoming the new conditions set up by balloon tires and more resilient car springs.

Not an old device revamped to meet present conditions, but a NEW device in every way engineered to do the present job of making balloon tires behave.

The Hassler Stabilizer is new in PRINCIPLE—for it employs SMOOTH FRICTION instead of rough friction to control the upthrow of the automobile spring.

It is new in ECONOMY, for, in addition to being moderate in price, its mechanism is SEALED against the destructive road dirt which would otherwise wear out its working parts

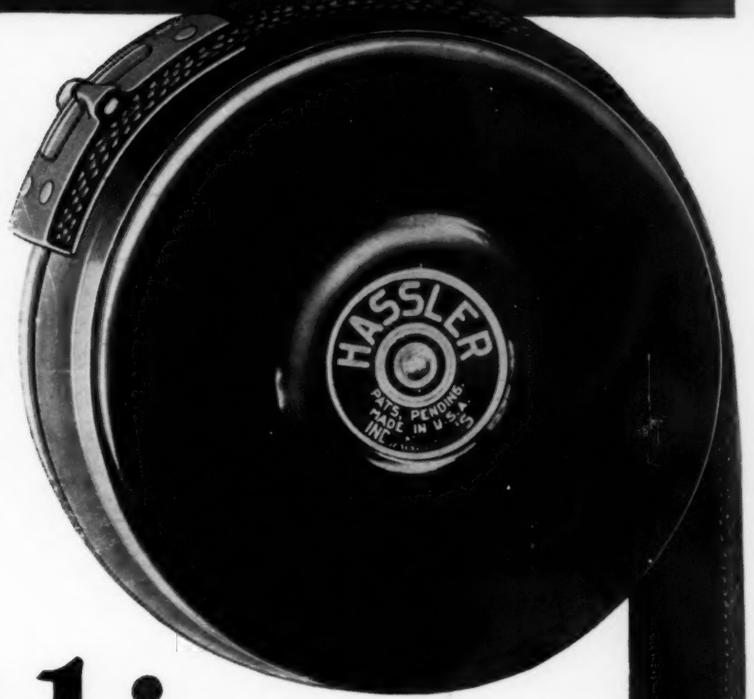
—its belt is a connecting link only—free from breaking strains—and in case of accidental breakage can be detached without disassembling the Stabilizer—in itself a big economy measure.

It is new in its FREEDOM from noises.

And it is new in that it can be LUBRICATED—just as you lubricate the OTHER working parts of your car. That one feature, alone, means longer life and more efficient service.

Isn't it logical that the Hassler Stabilizer is hailed all over the country as the greatest advance yet made in the science of COMFORTABLE transportation?

Robert H. Hassler, Inc.,



Stabilizer

to Motoring Comfort

Nation Wide Distributor Organization

For the convenience of motorists and dealers, there is a Hassler Distributing Office in every recognized automotive distributing center. Dealers can get deliveries or service in a minimum of time, by getting into communication with the nearest Hassler Office:

Hassler Pacific Company
1201 Van Ness Ave., San Francisco, Calif.
1315 S. Figueroa St., Los Angeles, Calif.
316 E. Pike St., Seattle, Wash.

Hassler Colorado Company
1073 Broadway, Denver, Colo.

Hassler Oklahoma Company
711 N. Broadway, Oklahoma City, Okla.

Hassler Texas Company
1101-03 Young St., Dallas, Texas
1715 Main St., Houston, Texas
612 Broadway, San Antonio, Texas

Hassler Nebraska Company
2572 Harney St., Omaha, Nebr.

Hassler Missouri-Kansas Company
1529 Grand Ave., Kansas City, Mo.

Hassler St. Louis Company
2841 Locust Blvd., St. Louis, Mo.

Hassler Minnesota Company
413 N. Franklin St., St. Paul, Minn.
1108 Harmon Place, Minneapolis, Minn.

Hassler South East Company
1055 Union Ave., Memphis, Tenn.
417 S. 21st St., Birmingham, Ala.
1331 St. Charles St., New Orleans, La.
224 Adams, Jacksonville, Fla.

Hassler Neff Company
545 Broadway, Milwaukee, Wis.

Hassler Chicago Company
2023 S. Michigan Ave., Chicago, Ill.

Habig Mfg. Company
1035 N. Meridian St., Indianapolis, Ind.

Hassler Kentucky Company
739 E. Breckinridge St., Louisville, Ky.

Hassler Ohio Company
501 Clinton Bldg., Columbus, Ohio

Hassler Toledo Company
341 20th St., Toledo, Ohio

Hassler Sales Agency, Inc.
521 E. Main St., Richmond, Va.

Hassler Cleveland Company
2024 E. 79th St., Cleveland, Ohio

Hassler New England Company
884 Commonwealth Ave., Boston, Mass.

Hassler Cincinnati Company
215 E. 7th St., Cincinnati, Ohio

Hassler Philadelphia Company
2827 N. Broad St., Philadelphia, Pa.

Harry Fried
1726 N. Charles St., Baltimore, Md.

Electrical Equipment Service Company
5157 Liberty Ave., Pittsburgh, Pa.

Hibner Hoover Hardware Company
17-21 N. Brady St., DuBois, Pa.

Tri State Motor Company
320 W. San Antonio St., El Paso, Texas

Hassler Dakota Company
3-5 Ninth St., S., Fargo, N. Dak.

Eckburg Auto Company
310 Ionia, N. W., Grand Rapids, Mich.

Hassler Scranton Company
1431 Mulberry St., Scranton, Pa.

Buffalo Ignition Sales, Inc.
1439 Main St., Buffalo, N. Y.

Kirk Auto Supply Company
226 W. Genesee St., Syracuse, N. Y.

Clark Equipment Company
West End Ave., at 65th St., New York, N. Y.

Balloon Tire Control

Popular Price

Simple Installation

No Broken Straps

Sealed Construction

Indianapolis, U. S. A.

McKay Popularity

Here are two big reasons for using McKays as standard equipment on your line of cars:

First: They add to the beauty of the most beautiful car.

Second: They protect that beauty for the life of the car.

Let us tell you the complete McKay story.

UNITED STATES CHAIN & FORGING COMPANY
UNION TRUST BUILDING PITTSBURGH, PA.

McKAY RED BEAD BUMPERS

McK

And, equally important, McKay Red Bead Bumpers will help your dealers sell cars.

Everywhere-

THE Gruss Twins are protecting buses from road shock and vibration.

Naturally this means less breakage—smaller repair bills—fewer lay-ups, increased patronage due to supreme comfort. 166% sales increase last year proves it!

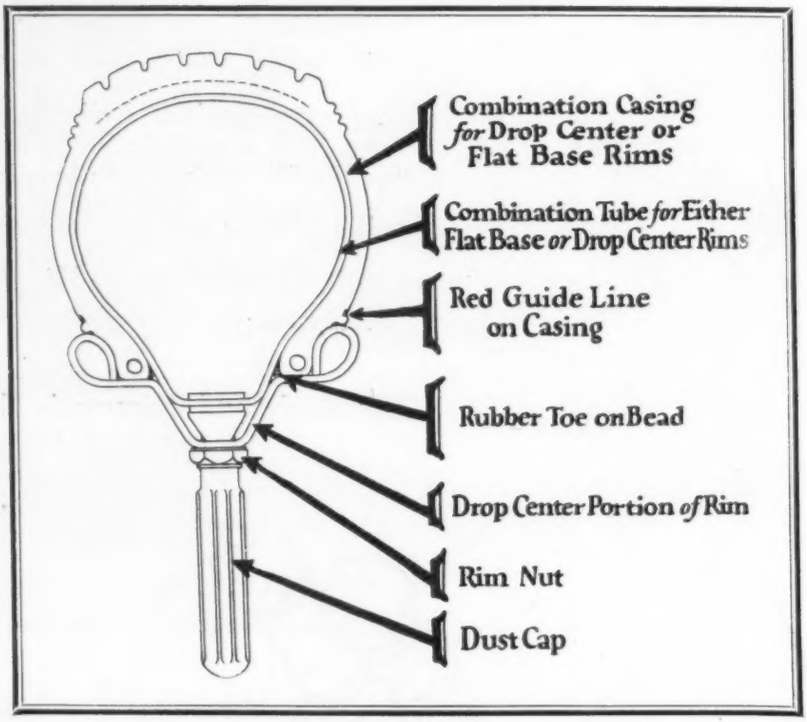
The Cleveland Pneumatic Tool Co.
Cleveland, Ohio

GRUSS AIR SPRINGS

for Trucks, Buses
Passenger Cars ~

UNITED STATES TIRES ARE GOOD TIRES

A Forward Step in Tire Mounting


Combination Casing for Drop Center or Flat Base Rims
Combination Tube for Either Flat Base or Drop Center Rims
Red Guide Line on Casing
Rubber Toe on Bead
Drop Center Portion of Rim
Rim Nut
Dust Cap

THE "Drop Center" rim has been accepted as a decided forward step in tire mounting. Thousands of these rims are proving successful today on Ford cars and manufacturers of other cars are investigating the possibilities of this type of mounting.

The development is directly in line with the best automotive engineering principles—reduction of unsprung weight and increased simplicity of operation.

United States Rubber Company engineers, in cooperation with engineers of the Ford Motor Company, have found that it is not necessary to design a special casing and tube to fit this new type of rim.

They have been able to effect certain modifications in the Company's standard 29 x 4.40 Royal Cord Balloon casing and tube, which permit them to fit equally well the regular Flat Base Rim or the new Drop Center Rim.

United States Rubber Company

TRADE MARK

Cut Out WASTE in Sandblasting

In our study of industrial plants, we are often amazed at the **waste** that is being permitted in the sandblasting department of industries which are otherwise well-managed.

This waste takes several forms:

1. Excessive air-pressures — air-power being the largest cost-item in sandblasting.
2. Nozzles of unnecessarily large diameters.
3. Excessive time to the load or turn.
4. Lack of skill of operators.
5. Use of inefficient sandblast abrasives.

(1) **Excess air pressure** is usually due to the fact that the sandblast department is served by branch lines from compressors operating at 90 to 100 lbs. pressure—when 60-70 lbs. is all that is needed in sandblast work when Flint Shot is used. In such cases we advise the insertion of a pressure-reducer in the line.

(2) **The use of over-size nozzles** multiplies this air waste—whether the mistake is that of starting with too large nozzles or continuing the use of nozzles after the openings are enlarged by use.

(3) Our engineer is frequently able to show sandblasters how they can reduce sandblasting time 50% —some times more.

(4) Sandblast operators are frequently allowed to work without proper instructions and direction.

(5) The test of the economy of an abrasive is not its first cost, but the amount of **work** it does per dollar of that cost. We demonstrate that FLINT SHOT works faster, lasts longer and does **more** work and **better** work than any other mineral abrasive, with less air-cost per ton of material cleaned. And our findings of the **cost** of sandblasting with **Flint Shot,** compared with **metallic** abrasives, are so startling that metallic abrasives are usually abandoned forthwith by executives who witness the tests.

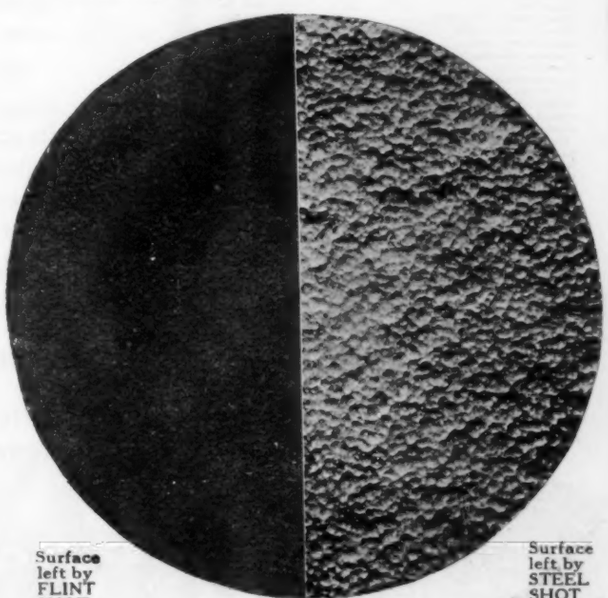
UNITED STATES SILICA Co
122 South Michigan Ave. Chicago

Character of Work Done

Flint Shot, because of the uniformity in size, contour and hardness of its non-splitting flint granules, gives Flint-Shotted surfaces a uniform velvety matté finish not attainable with any other abrasive. See micrograph below.

Our Free Trial Offer

To sandblasters now using other sandblast abrasives, we will ship **free of charge,** as many 150-lb. bags of FLINT SHOT as are necessary for a thorough working test.



Surface left by FLINT SHOT at 60 lbs. Pressure

Micrograph of Malleable Casting

Surface left by STEEL SHOT No. 26 at 60 lbs. Pressure

A striking illustration of the rust resisting properties of Certified Malleable. Two screw spikes that were put in service at the same time. The one on the left is Certified Malleable.

Pole reinforcement of Certified Malleable Iron. Rust resistance combined with great strength is essential in this device.

Certificate Holders During Quarter Ending June 30th, 1926

Albany Malleable Iron Co. ..... Voorheesville, N. Y.
Albion Malleable Iron Co. ..... Albion, Mich.
American Chain Co. ..... Bridgeport, Conn.
American Malleable Castings Co. ..... Marion, O.
American Malleables Co. ..... Lancaster, N. Y., and Owosso, Mich.
Badger Malleable & Mfg. Co. ..... South Milwaukee, Wis.
Baltimore Malleable Iron & Steel Casting Co. ..... Baltimore, Md.
Belle City Malleable Iron Co. ..... Racine, Wis.
Chain Belt Co. ..... Milwaukee, Wis.
Chicago Malleable Castings Co. ..... West Pullman, Chicago, Ill.
Columbia Malleable Castings Co. ..... Columbia, Pa.
Columbus Malleable Iron Co., The ..... Columbus, O.
Danville Malleable Iron Co. ..... Danville, Ill.
Dayton Malleable Iron Co., The ..... Dayton, O., Ironton, O.
Decatur Malleable Iron Co. ..... Decatur, Ill.
Devlin Mfg. Co., Thomas ..... Philadelphia, Pa.
Eastern Malleable Iron Co., The ..... Naugatuck Malleable Iron Works, Naugatuck, Conn.; Bridgeport Malleable Iron Works, Bridgeport, Conn.; Troy Malleable Iron Works, Troy, N. Y.; Wilmington Malleable Iron Works, Wilmington, Del.; Vulcan Iron Works, New Britain, Conn.
Erie Malleable Iron Co. ..... Erie, Pa.
Federal Malleable Co. ..... West Allis, Wis.
Fort Pitt Malleable Iron Co. ..... Pittsburgh, Pa.
Fraser & Jones Co. ..... Syracuse, N. Y.
General Electric Co. ..... Erie, Pa.
Glancy Malleable Corporation ..... Waukesha, Wis.
Illinois Malleable Iron Co. ..... Chicago, Ill.
Iowa Malleable Iron Co. ..... Fairfield, Ia.
Kalamazoo Malleable Iron Co. ..... Kalamazoo, Mich.
Lacoma Car Co. ..... Laconia, N. H.
Lakeside Malleable Castings Co. ..... Racine, Wis.
Link-Belt Co. ..... Indianapolis, Ind.
Marion Malleable Iron Works ..... Marion, Ind.
Moline Malleable Iron Co. ..... St. Charles, Ill.
National Malleable & Steel Castings Co. ..... Cleveland, O., Chicago, Ill., Indianapolis, Ind., Toledo, O., E. St. Louis, Ill.
Northern Malleable Iron Co. ..... St. Paul, Minn.
Northwestern Malleable Iron Co. ..... Milwaukee, Wis.
Peoria Malleable Castings Co. ..... Peoria, Ill.
Pittsburgh Malleable Iron Co. ..... Pittsburgh, Pa.
Rhode Island Malleable Iron Works ..... Hillsgrove, R. I.
Rockford Malleable Iron Works ..... Rockford, Ill.
Rou-Mochan Foundries, The ..... Chattanooga, Tenn.
St. Louis Malleable Casting Co. ..... St. Louis, Mo.
Saginaw Products Co. ..... Saginaw, Mich.
Standard Malleable Castings Co. ..... Terre Haute, Ind.
Stowell Co., The ..... South Milwaukee, Wis.
Superior Steel Castings Co. ..... Benton Harbor, Mich.
Symington Co., The ..... Rochester, N. Y.
Temple Malleable Iron & Steel Co. ..... Temple, Pa.
Terre Haute Malleable & Mfg. Co. ..... Terre Haute, Ind.
Trenton Malleable Iron Co., The ..... Trenton, N. J.
Union Malleable Iron Co., The ..... E. Moline, Ill.
Vermilion Malleable Iron Co. ..... Hoopeston, Ill.
Wagner Malleable Castings Co. ..... Hammond, Ind., and Beloit, Wis.
Warren Tool & Forge Co. ..... Warren, O.
Webster Mfg. Co., The ..... Chicago, Ill.
Wisconsin Malleable Iron Co. ..... Milwaukee, Wis.
York Mfg. Co. ..... York, Pa.
Zanesville Malleable Co. ..... Zanesville, O.

Rust Resistance

Rain, snow, mud and other corroding agents take a daily toll from vital parts of farm implements, automotive and general industrial machinery. Wherever Certified Malleables are used they will cut down repairs and maintenance costs due to these factors.

Because it is essentially one of the purest forms of iron, due to the method of "heat treating" or annealing, Certified Malleable is more resistant to rust than other forms of iron and steel.

This superior material therefore offers a combination of valuable physical properties not found in any other single product. It combines rust resistance, great strength and light weight, ease and economy in machining, toughness, ductility, and resistance to shock and abuse.

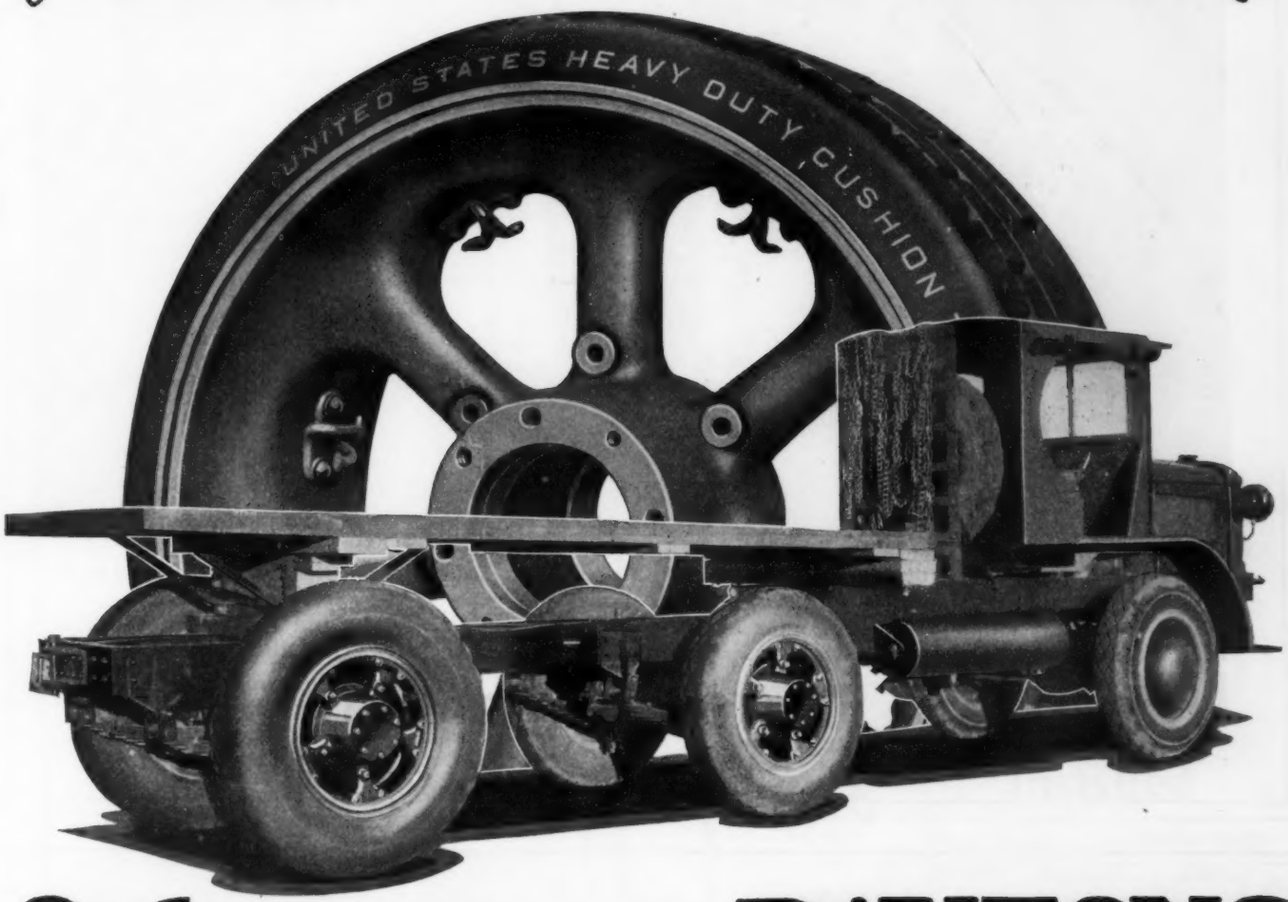
Certified Malleables are uniform in structure and other physical properties. They regularly exceed 50,000 lbs. tensile strength, 10% elongation and 30,000 lbs. yield point.

AMERICAN MALLEABLE CASTINGS ASSOCIATION
UNION TRUST BUILDING CLEVELAND, OHIO

POSITIVE PHYSICAL PROPERTIES — AcA CERTIFIED TRADE MARK

CERTIFIED-MALLEABLE CASTINGS

TIRE ECONOMY ~ ACCESSIBILITY ~ APPEARANCE



Coleman *uses* DAYTONS

The Coleman Four-Wheel Drive Truck is used widely by the United States Army and in the lumber, mining and oil industries, in road building and road clearing, etc.

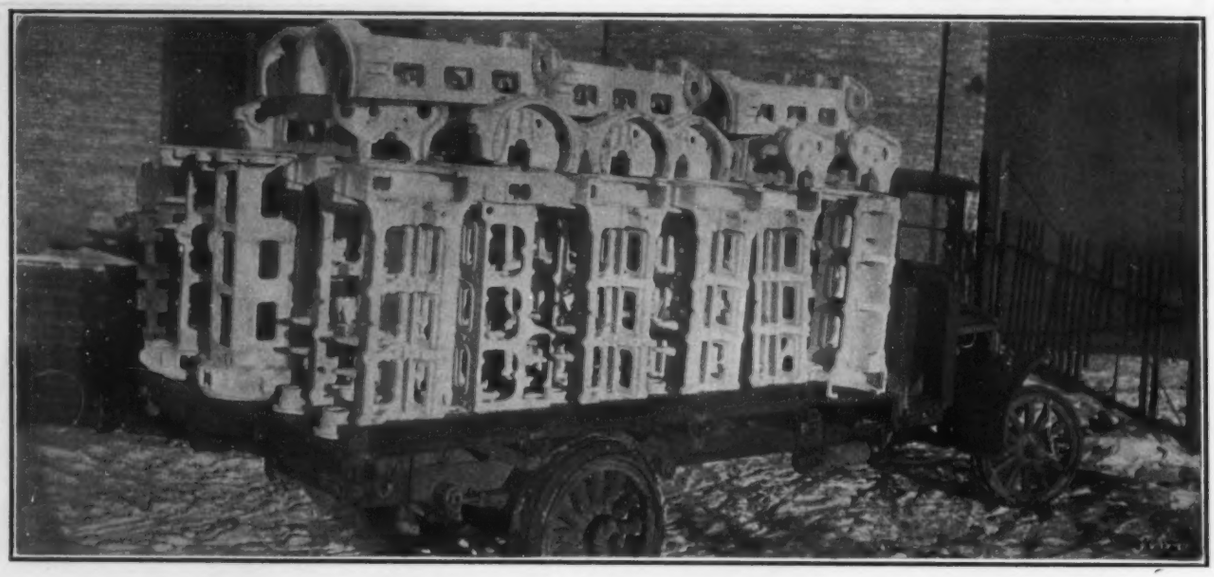
The front wheel drive is a notable feature of the Coleman Truck. A powerful—easy steering—economical truck equipped with wheels of super-strength—easy steering wheels—wheels that make for economical transportation—Dayton Steel Wheels.

Nearly all the leading truck makers use Dayton Steel Wheels. Specify them for your trucks.

THE DAYTON STEEL FOUNDRY COMPANY, Dayton, Ohio

Dayton
Steel Truck Wheels
PATENTED

STRENGTH ~ LIGHT WEIGHT ~ DURABILITY



The above is a load of Bus Castings which is part of an order ready for shipment to one of the leading Bus Engine Manufacturers.

We solicit your inquiries for *Motor Bus, Taxicab, Automobile, Truck* and *Radiator Shell Castings.* We are equipped to make castings of all descriptions. Capacity 25,000 lbs. per day.

QUALITY ALUMINUM CASTING CO.

WAUKESHA, WIS.

The **HOOPES** **METAL FELLOE WHEEL**

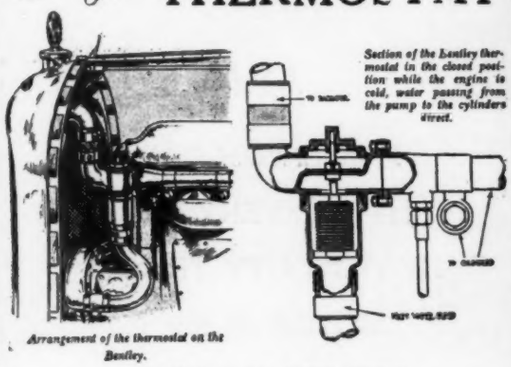
A Wood Spoke, Metal Felloe Truck Wheel which eliminates unnecessary unsprung weight and thereby makes a continuous saving for the operator.

Send for Descriptive Literature

Hoopes, Bro. & Darlington, Inc.

1867 WEST CHESTER, PA. 1926

Sylphon TRADE MARK AUTOMOBILE THERMOSTAT



Section of the Bentley thermostat in the closed position while the engine is cold, water passing from the pump to the cylinders direct.

Arrangement of the thermostat on the Bentley.

As installed on the British Bentley. Standard equipment on 25 other foreign and domestic cars and trucks of the better class.

Installed on the cooling system, a Sylphon Automobile Thermostat not only controls the temperature of the engine automatically at the degree of greatest efficiency, and reduces carbon deposits, crankcase dilution and gasoline consumption, but it also has this

EXCLUSIVE SAFETY FEATURE

If the thermostatic element should get damaged, allowing the volatile liquid to escape, the valve will move to a position of safety, and the cooling water will flow unrestricted through the radiator

Write for Bulletin JUR

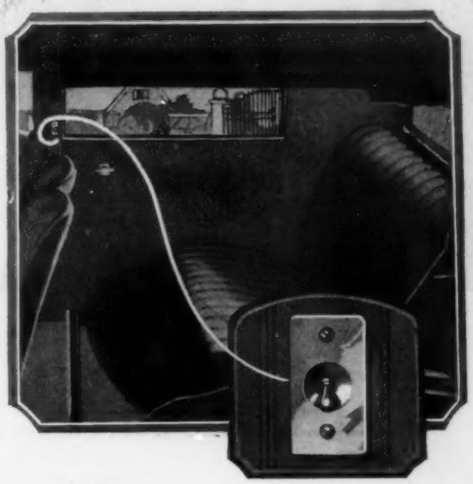
THE FULTON COMPANY
KNOXVILLE, TENN.

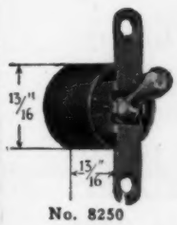
ORIGINATORS AND PATENTEES OF THE SYLPHON BELLOWS

Sales Office in
New York, Chicago, Detroit, Boston, Philadelphia

and all the principal cities in U. S.
European Representatives: Delco-Remy & Hyatt, Ltd., 111 Grosvenor Road, London, SW 1, England

HUBBELL *Toggle Switches*





No. 8250

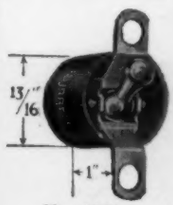
Quickly and easily installed

Just bore a 7/8" hole and insert switch. Easily wired—binding screws are large and very accessible.

No. 8250 with
No. 8251 Plate

Equipped with strong, easily-operated toggle mechanism with smooth, positive action.

A high-grade switch of simple, durable construction, adapted for speedy installation requirements.



No. 8260

Made in flush and recessed types. Plates in any finish.

Write for samples. See how well-made these switches are and how quickly they can be installed.

No. 8260 with
No. 8261 Plate

HARVEY HUBBELL INC.
ELECTRICAL SPECIALTIES
BRIDGEPORT, CONNECTICUT, U.S.A.
NEW YORK, N.Y. CHICAGO, ILL.

HUBBELL

SHAFER
"Self-Aligning"
ROLLER BEARING
"We want to take this opportunity to let you know the satisfaction we have experienced in the use of Shafer Bearings in Maxwell and Chrysler cars which we service. The Bearings used as original equipment and for replacement give long and satisfactory service."
—Chatham Motor Co., Savannah, Ga.
SHAFER BEARING CORPORATION
6501 West Grand Avenue
CHICAGO, ILL.

Sheldon

AXLES SPRINGS BUMPERS

FOR

PASSENGER CARS

LIGHT DELIVERY TRUCKS

HEAVY DUTY TRUCKS

MOTOR BUSSES

TAXI CABS

Sheldon Axle & Spring Co.

WILKES-BARRE PENNSYLVANIA

We Have Expanded with the Industry

—from a small shop working in sheet metal to an organization producing steel products for many of the largest manufacturers of cars, trucks and tractors.

Because of our growth, and the much wider scope of our service in the fabrication of automotive and industrial steel products, we will be known in the future as the STOLPER STEEL PRODUCTS CORPORATION, instead of A. B. & B. Sheet Metal Works.

In this connection we also have completed the re-equipment of our plant, with the most improved labor and time saving machinery, and in April we will start on our plant addition, which will materially increase our manufacturing capacity.

Our organization remains intact, and it is the aim of every member of it to see that our policy of "Service to the Customer" never varies.

Stolper Steel Products Corporation

FORMERLY A. B. & B. SHEET METAL WORKS
Fond du Lac Ave. at 33rd St. Milwaukee, Wis.

DAHLSTROM
Metal Mouldings & Shapes

Unequalled in
Quality—Design
Strength—Finish

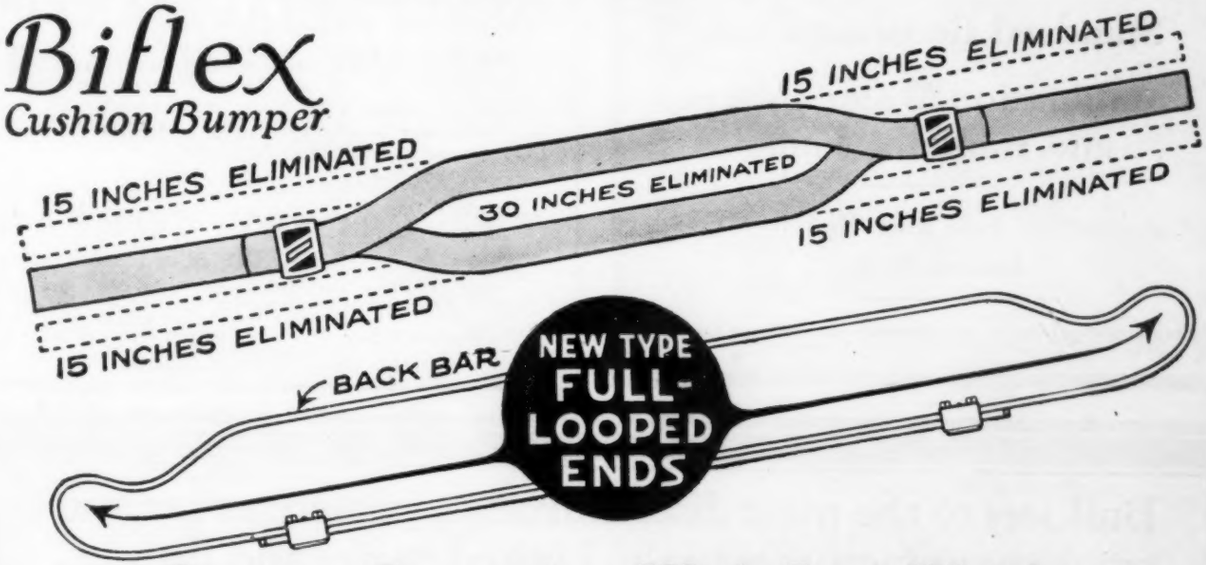
DAHLSTROM METALLIC
DOOR COMPANY

435 Buffalo Street Jamestown, New York

NEW YORK 25 Broadway
PHILADELPHIA 514 Bulletin Building
DETROIT Room 5-251 General Motors Bldg.

Local Representatives in All Principal Cities

Biflex
Cushion Bumper



Greater Protection With Less Weight

Biflex has practically the same buffing area of three parallel steel bars with but only the weight of two. The dotted lines show how the weight of Biflex Bumpers is reduced by eliminating unnecessary parts of each bumper bar. The protective qualities of the bumper, however, are increased through the scientific hoop-like construction, full looped and supported ends with maximum cushioning depth.

Biflex Bumper bars weigh 2.78 lbs. per foot. A total of 90 inches, 7½ ft. of bar, is eliminated from the three parallel bars by the ingenious and scientific construction. So Biflex, giving the highest degree of bumper protection, weighs only 38 lbs. The overhang weight is reduced to the very minimum due to the construction which brings the back bar practically flush with the end of the chassis. Thus the center of gravity is close to the car; the weight is properly distributed and balanced. Biflex represents the highest development in bumpers, maximum protection with minimum overhang weight.

THE BIFLEX CORPORATION, WAUKEGAN, ILL., Export Department, 130 West 42nd Street, New York City

(75)

THE CANTON DROP FORGING AND MFG. CO.

Office and Works: CANTON, OHIO

Drop Forgings for Particular Users
Since 1903

AUTOMOBILE LAMPS

We are completely equipped to produce motor vehicle lamps, whether of electric, gas or oil construction, in any quantity desired. We solicit the privilege of submitting samples and quoting prices.

The Jno. W. Brown Mfg. Company
Columbus Ohio

Closed - Body - Interior - Trimmings

Wind Lace	Robe Rails
Seaming Lace	Assist Cords
Pasting Lace	Curtain Cords
Broad Lace	Curtain Tassels
Moulding	Curtain Materials
Carpet Binding	Package Nets

Schlegel Manufacturing Company
Rochester New York

Standard Radiator Fans

Combination Water Pumps and Radiator Fans

Automotive Fan and Bearing Co.
Jackson, Mich.

Standard Equipment on America's Best Motor Cars

SHEET METAL STAMPING

We are building axle housings, brake drums, and other parts for the heaviest motor trucks ever built, and have ample capacity for still heavier.

With our complete equipment we cover the entire sheet metal stamping line.

We solicit your inquiries.

THE CROSBY COMPANY
BUFFALO, N. Y.

New York Office: 30 Church St.
Cleveland Office: 334 Union Mortgage Bldg.
Detroit Office: 1709 Ford Bldg.
Philadelphia Office: 7302 Germantown Ave., Germantown, Philadelphia, Pa.
Chicago Office: 530 Transportation Bldg.

Builders to the most discriminating passenger car and truck manufacturers in the United States and Europe.

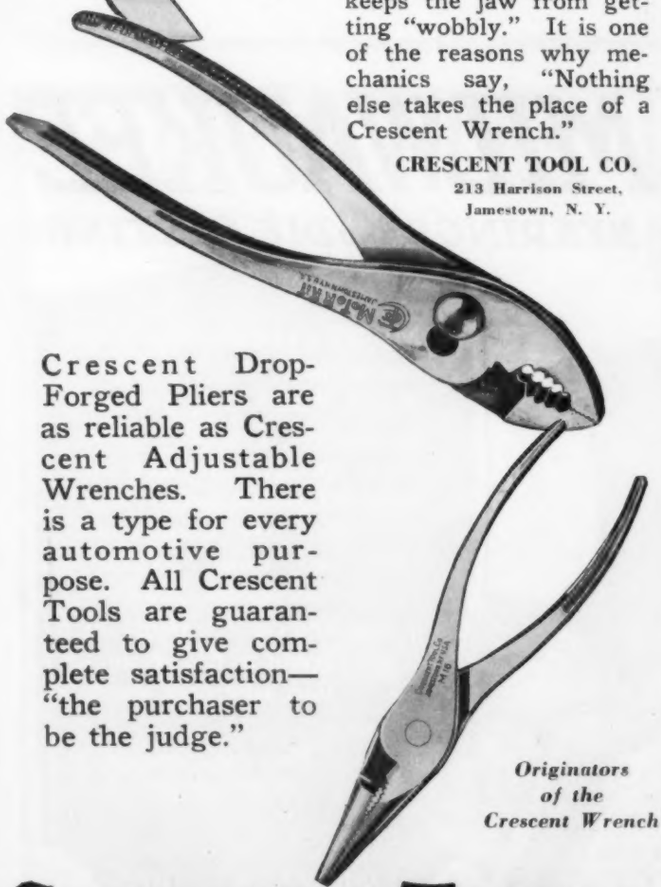
STANDARD STEEL SPRING COMPANY
CORAOPOLIS, PA.
MANUFACTURERS of LEAF SPRINGS

Crescent Wrenches are not fed through the calender rolls of rubber manufacturing plants as a usual thing, but when it does happen, as it did to the one pictured below, the result shows how Crescent heat treated steel resists crumbling or flaking under hundreds of tons of pressure.

Resisting *wear* as well as *breakage*

The toughness of Crescent heat treated steel protects the wrench from breakage when dropped or when given rough treatment — but it is the hardened surface produced by the Crescent carbonizing process that keeps the adjusting threads sound and smooth. That is what keeps the jaw from getting "wobbly." It is one of the reasons why mechanics say, "Nothing else takes the place of a Crescent Wrench."

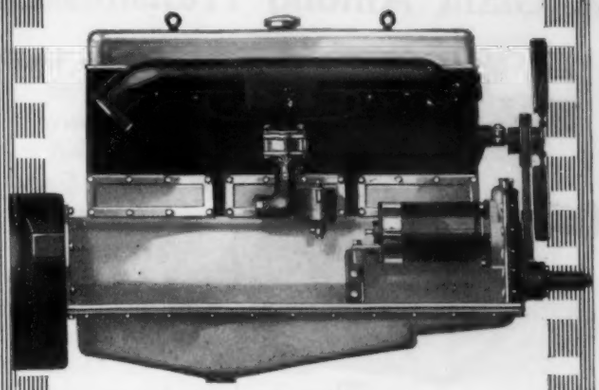
CRESCENT TOOL CO.
213 Harrison Street,
Jamestown, N. Y.



Crescent Drop-Forged Pliers are as reliable as Crescent Adjustable Wrenches. There is a type for every automotive purpose. All Crescent Tools are guaranteed to give complete satisfaction—"the purchaser to be the judge."

Originators of the Crescent Wrench

CRESCENT TOOLS



More per Cubic Inch—and per Dollar!

Choose any motor from this full line of finer Fours and Sixes, and you can depend upon it to deliver consistently the "More Power per Cubic Inch" for which all Wisconsin Motors are famous.

Overhead-valve design, as developed by Wisconsin, is responsible for the longer life—lower repair and replacement costs—simplified servicing — amazing fuel-and-oil economy of these great motors.

Write for the facts and the proofs.

Wisconsin Motor Mfg. Co.
Milwaukee, Wisconsin

MORE POWER per CUBIC INCH

Wisconsin Motors are manufactured in a full line of Sixes and Fours, with a power range from 20 to 120 H.P.—for trucks, buses, tractors and construction machinery.

Wisconsin CONSISTENT

A Giant Among Transmissions

Brown-Lipe Gear Model 60 Four-Speed Top Shift Main Frame Transmission

Where loads are heavy and roads are rough this model transmission proves its great worth.

Only accident or misuse will stop its quiet, efficient operation, and then new, genuine parts are quickly obtainable.

Complete information on this and all other Models given on request.

BROWN-LIPE GEAR CO.

BROWN-LIPE GEAR COMPANY

SYRACUSE, N. Y.

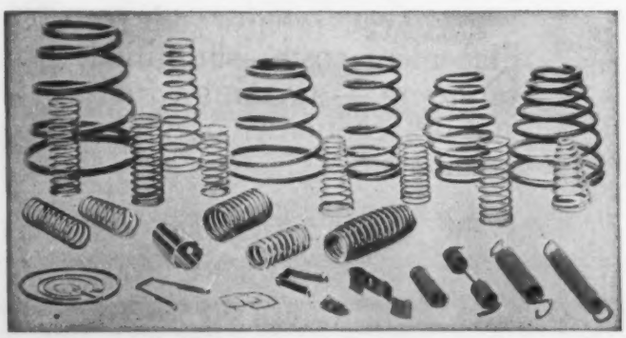
San Francisco Chicago Detroit New York London, Eng.

STEAM COOLING STEAM HEATING

Rushmore Laboratory

PLAINFIELD - - N. J.

SPRINGS



Few realize, even among engineers, how much of engineering design, proper calculation of stresses, metallographic selection of materials, and scientific heat treatment, is involved in the production of a high grade spring—

We realize all these things—AND DO THEM.

THE WM. D. GIBSON CO.
1800-1824 CLYBOURN AVENUE
CHICAGO ILL.

Manufacturers of All Types of Springs
Compression—Extension—Flat—Torsion

Any Size Any Material

Send for our treatise on springs.

MILWAUKEE

BEARINGS AND DIE CASTINGS

MILWAUKEE Bearings, precision-made, 100% virgin-metal, make ideal factory equipment. Ten inspections insure perfect bonding of back and babbitt, metal clean and solid, free from blow holes, and "mike"-accurate in all dimensions. Flawless quality and correct design do credit to the production wherever used.

May we exchange specifications?

MILWAUKEE DIE CASTING CO.
MILWAUKEE, WIS.

B.G.R.

SPRINGS

Chances are even at any rate that you are getting good springs, promptly and dependably, now. If you would like to get better springs, or want a little more prompt delivery, or a more convenient source, tell us about it.

We believe we can be of real service to the engineer on spring design, and our facilities are at your disposal.

We are equipped to make all types of round wire and small flat springs of any material.

BARNES-GIBSON-RAYMOND-INC.

MANUFACTURERS OF

SPRINGS OF ALL DESCRIPTIONS

6400 MILLER AVENUE

DETROIT, MICH.

OLSEN TESTING MACHINES

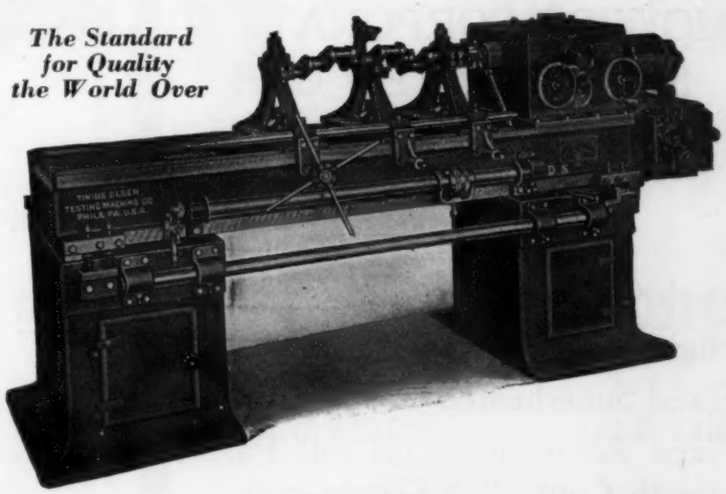
UNIVERSAL TESTING MACHINES for tension, compression and transverse tests of all metals and materials.

HARDNESS TESTING MACHINES for Brinell Hardness tests of all material including sheet metal.

DUCTILITY TESTING MACHINES for determining drawing quality of sheet metal. CEMENT, CONCRETE, CHAIN, ANCHOR, WIRE, ROPE, OIL, PAPER, CLOTH and Rubber Testing Machines.

TORSION IMPACT, REPEATED IMPACT, TOUGHNESS, ENDURANCE, WEAR, ALTERNATE STRESS and EFFICIENCY Testing Machines.

The Standard for Quality the World Over



OLSEN-CARWEN STATIC-DYNAMIC BALANCING MACHINES

Eliminate Vibration—Secure Perfect Balance with Speed and Economy

The Olsen-Carwen is made in many sizes and types to balance any rotating parts from the smallest to the largest rotor made. Now used by all the leading up-to-date automobile and motor manufacturers throughout the country.

SOLE MANUFACTURERS

TINIUS OLSEN TESTING MACHINE COMPANY

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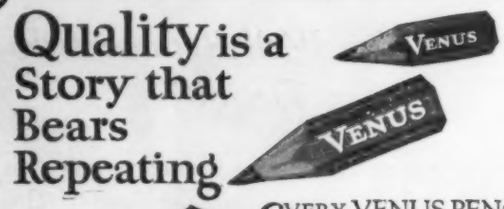

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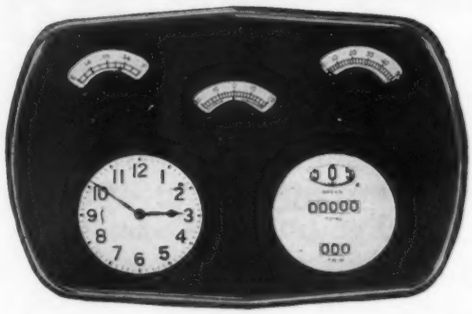

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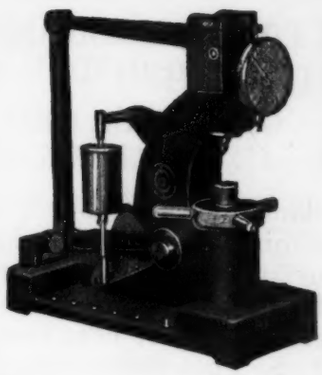

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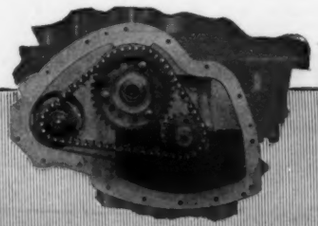

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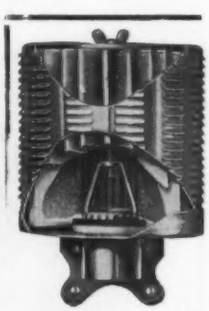

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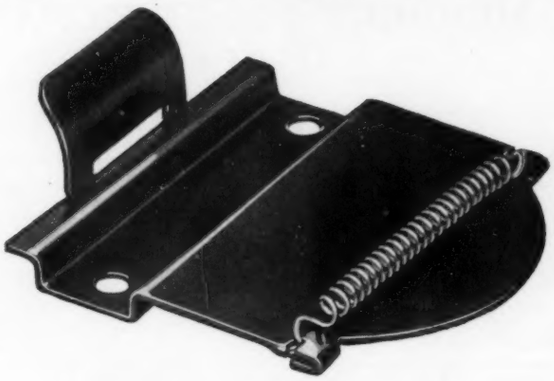

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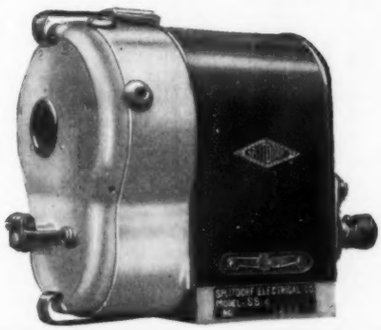

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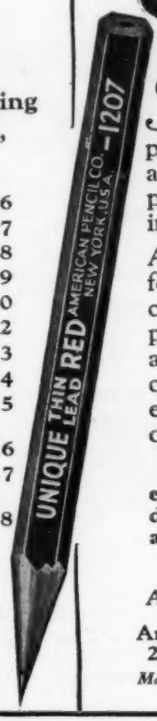

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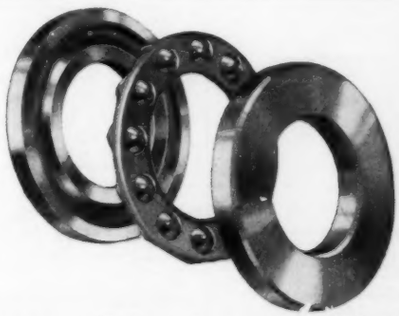

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*Ferry Cap & Set Screw Co.
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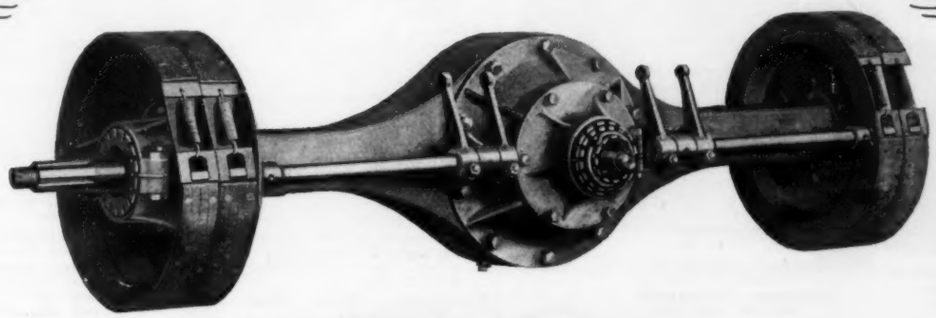
EXPLANATION OF SYMBOLS

Parts and materials followed by key numbers have been standardized by the S. A. E. The numbers refer to S. A. E. HANDBOOK data sheets on which each standard is published.

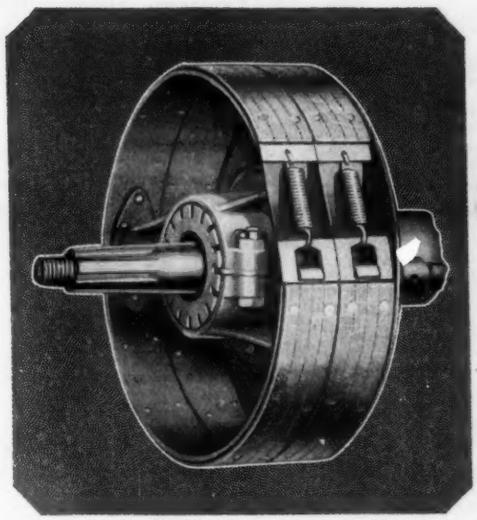
*Companies whose names are preceded by an asterisk supply the parts or materials under which the company is listed as conforming with the S. A. E. Standard referred to.

**Parts and materials followed by two asterisks indicate that two or more S. A. E. Standards are applicable. Information as to standards incorporated should be obtained from the manufacturer.

The address of companies listed in this index can be obtained from their current advertisements indexed on page 166.



CLARK



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DOUBLE COMPENSATING INTERNAL BRAKES

Clark Bevel Axles are equipped with double compensating internal brakes which provide more than adequate braking capacity.

Truck service must be continuous with as few interruptions as possible for service; with this idea in mind, our engineers have designed the ample brake equipment on Clark Axles.

Equalization of pressure on the entire periphery of the brake drum is assured on Clark Bevel Axles by the special compensating internal brake—plus exceptional ease in removal and replacement for quick relining.

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Clark Equipment Company

Buchanan, Mich.

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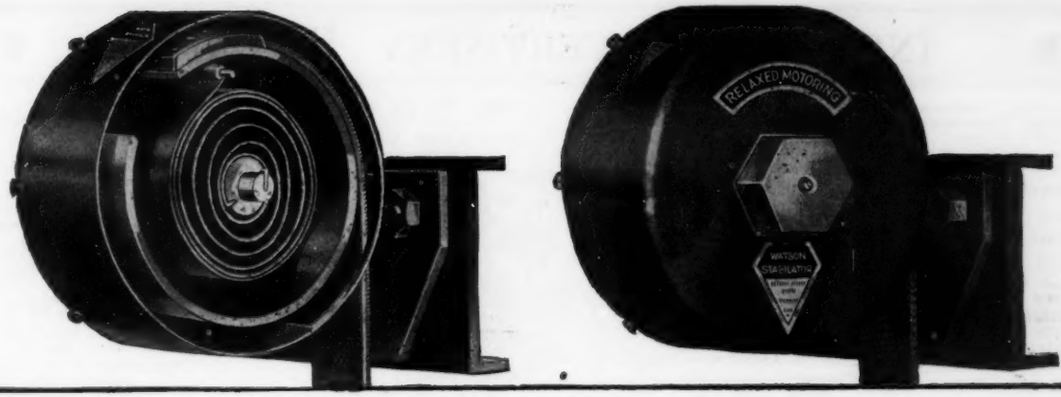
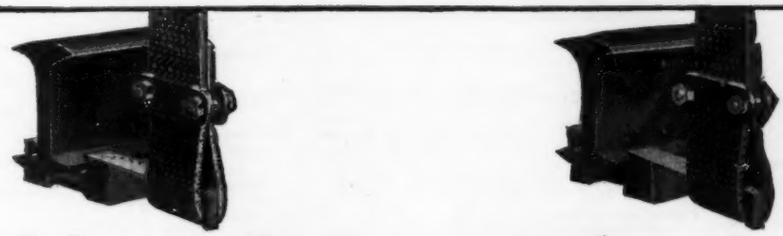


Quality Springs



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The known quality and outstanding durability of the Watson Stabilator bespeaks the quality and uniformity of our springs—which are used exclusively.

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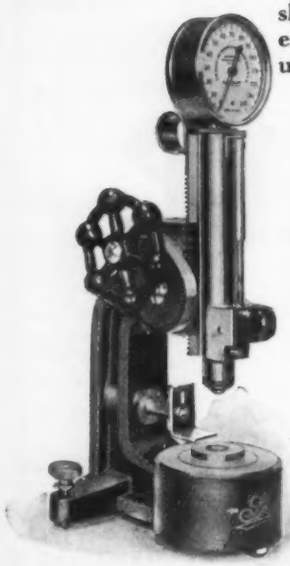

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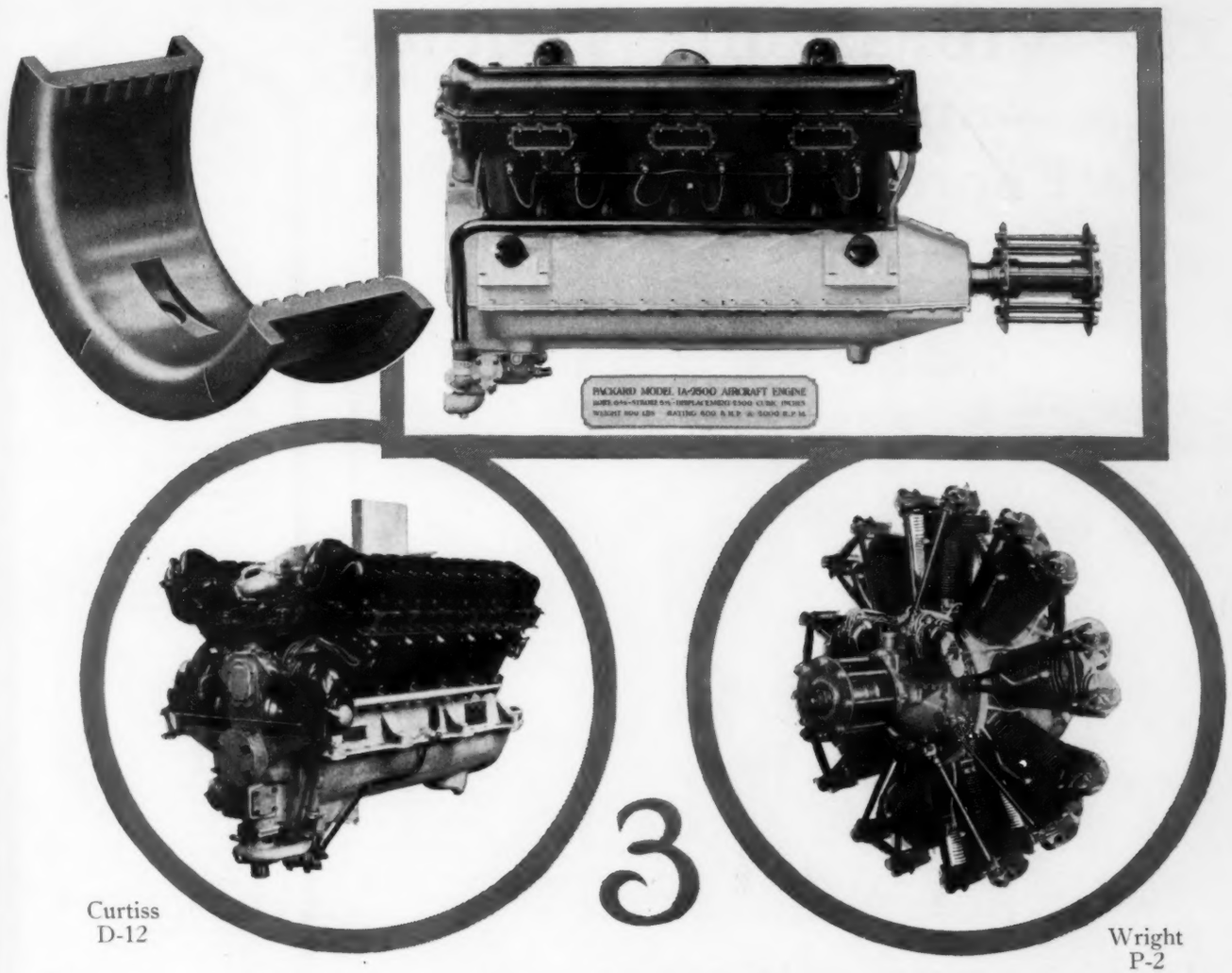

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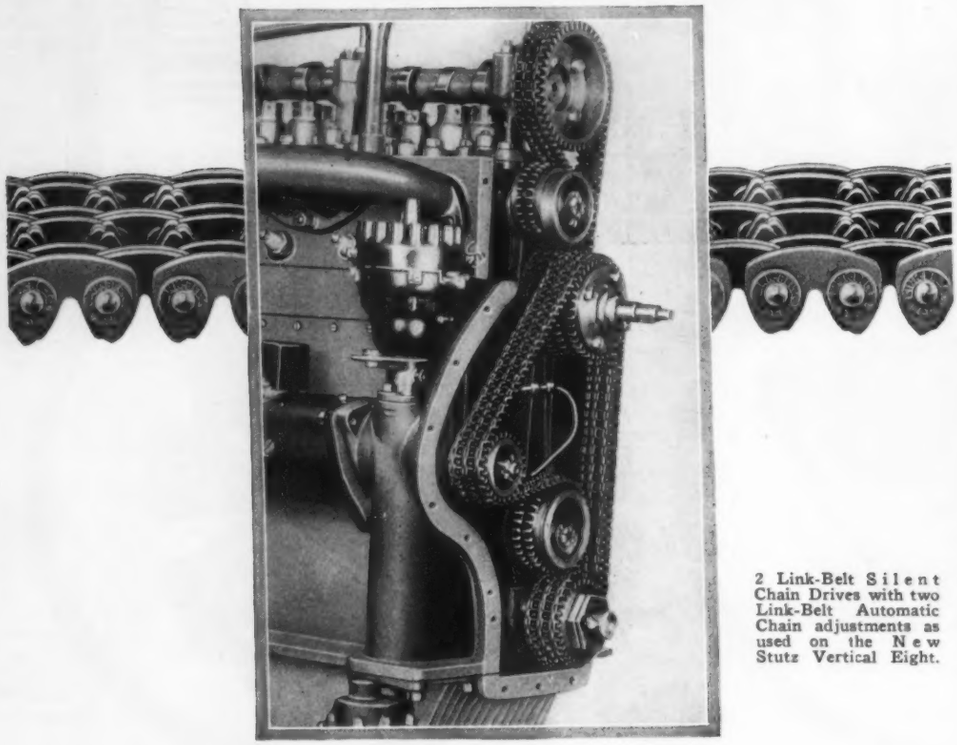

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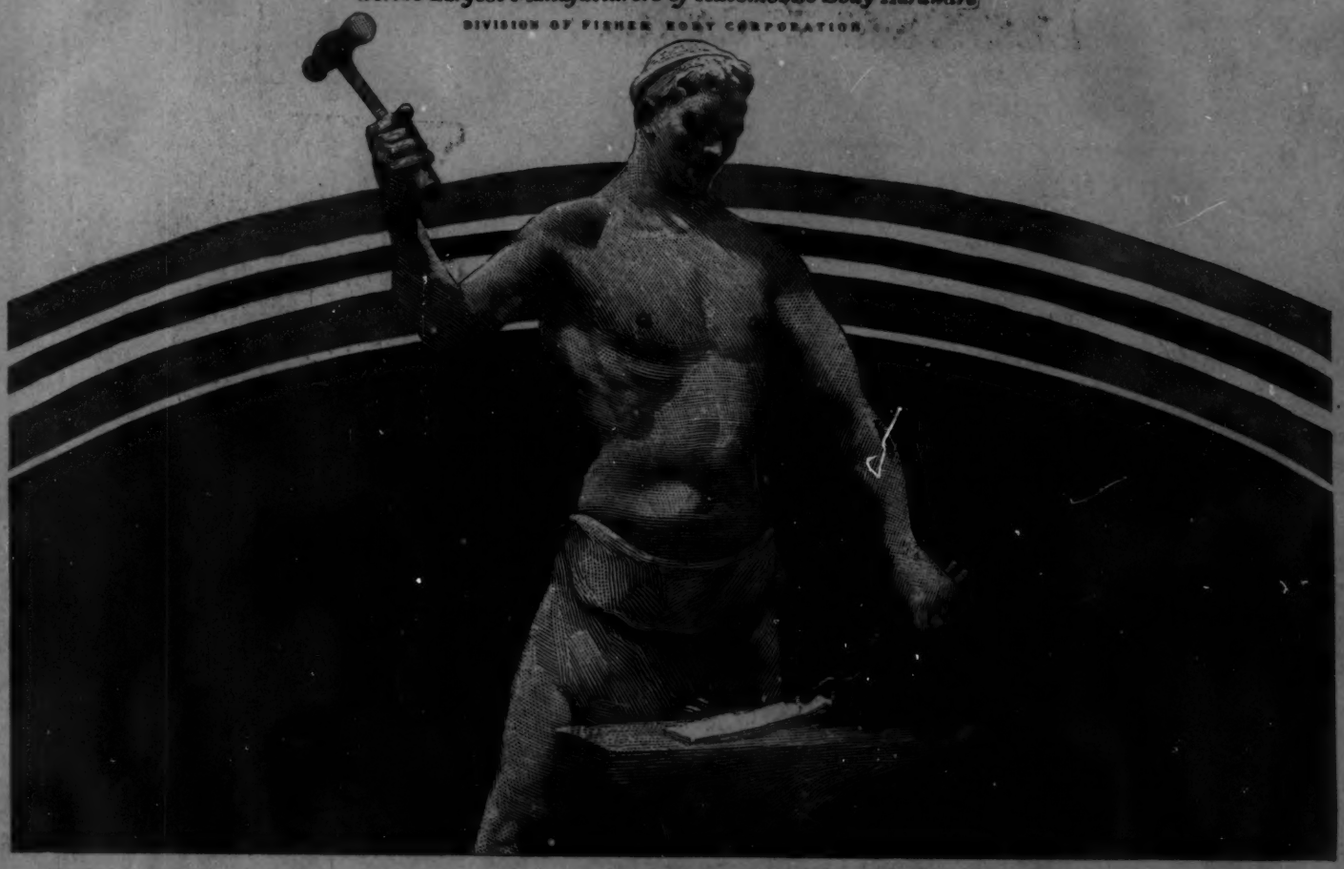

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